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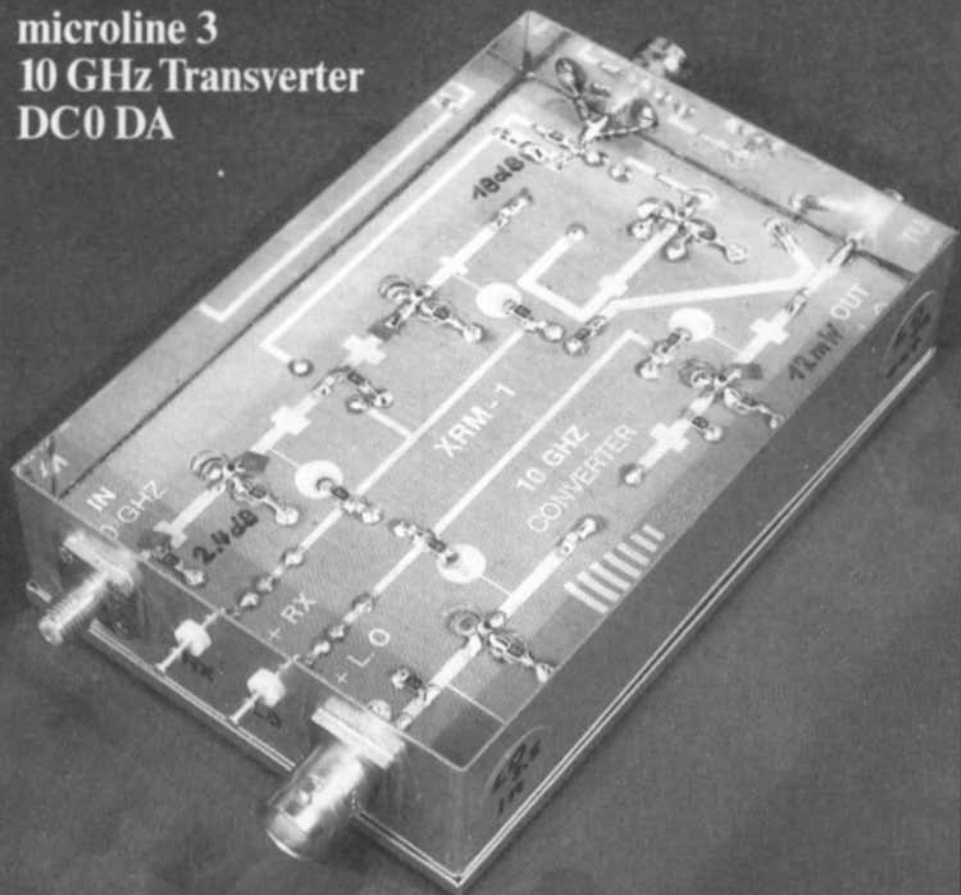
A Publication
for the Radio-Amateur
Especially Covering VHF,
UHF and Microwaves


VHF

communications

Volume No. 21 · Summer · 2/1989 · DM 7.50

**microline 3
10 GHz Transverter
DC0 DA**





VHF communications

A Publication for the Radio Amateur
Especially Covering VHF, UHF, and Microwaves

Volume No. 21 · Summer · Edition 2/1989

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Andrew Bell, GW 4 JJW

Circular Waveguide Components at 10 GHz

Most amateurs acquire only short lengths of rectangular waveguide purchased at prices ranging between £1 and £8 per foot. Whilst long lengths of waveguide are not needed for portable operation, they are often required for setting up fixed stations with roof-mounted antennas. At these prices WG16 proves rather expensive. However, a cheap and very effective alternative exists by way of conventional copper water pipe. This article describes the use of copper water pipe as circular waveguide. The author has installed such a system at his QTH and has made a variety of waveguide components using copper tube. Both 22 mm outer diameter (20 mm inner diameter) and 28 mm od (26 mm id) tubing may be used to carry 10 GHz radiation, provided the correct mode is used.

1. TE11 MODE IN CIRCULAR WAVEGUIDE

20 mm id (22 mm od) tube will carry 10 GHz radiation, provided mode TE11 is excited. TE11 is analogous to TE10 in rectangular waveguide. The modes TE10 and TE11 are shown diagrammatically in figures 1 and 2 respectively.

20 mm id tube operating in TE11 mode has the following characteristics: –

Cutoff frequency = 8.67 GHz

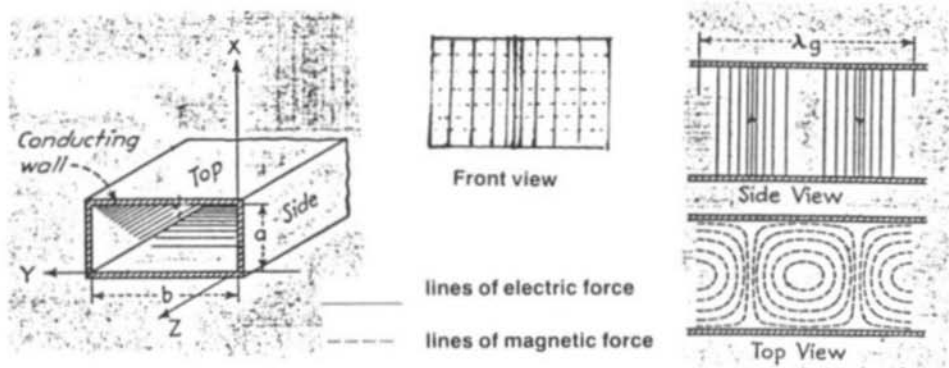
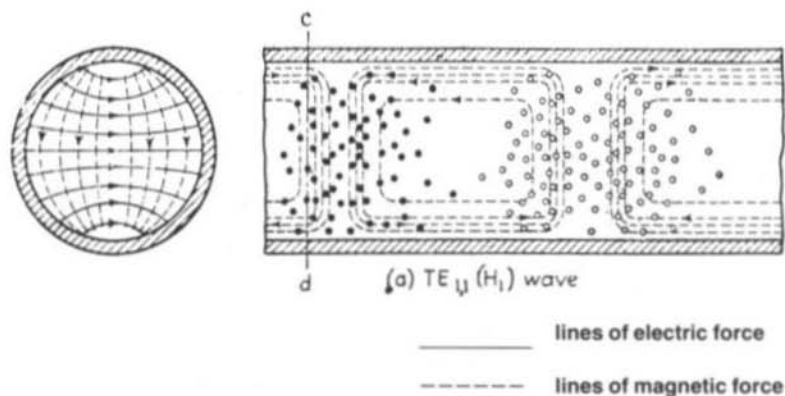
Cutoff wavelength = 3.46 cm

At 10.350 GHz the guide wavelength is 5.4827 cm. Formulae are given in Appendix 1.

In a rectangular waveguide the electric field is constrained to stay in one direction by the physical dimensions of the waveguide. However, in circular waveguide operating in TE11 mode, the electric field is not constrained and tends to rotate, owing to small discontinuities in the waveguide surface such as joints and bends. This is no problem if a rotatable joint is included somewhere in the system to correct for the rotational shift. The joint is rotated for maximum power and then soldered in this position. In this position the electric field will be in the correct orientation to excite the rectangular guide in TE10 mode. (Note, however, that if the waveguide is distorted or its length altered, the angular shift may need resetting.)

1.1. TE11 Circular Waveguide to TE10 Converter

Although circular waveguide is satisfactory for the main transmission runs, it is still preferable to originate or deliver the microwave radiation in rectangular waveguide for signal processing. The construction of a converter takes only about

Fig. 1: TE₁₀ mode in rectangular guideFig. 2: TE₁₁ mode in circular guide

30 minutes with simple hand tools. A photograph of this converter is shown in **figure 3**.

A length of 20 mm id copper tube which is at least 6 cm longer than the required length is selected. One end of this tube must be stretched slightly along its circumference and re-formed into rectangular cross section identical with WG16. This end will be forced through a WG16 flange. The flange is of the type such that WG 16 would normally go right through it.

First of all one end of the tube is squeezed in a vice which clamps the tube rigidly. The other

end of the tube is stretched by gently hammering two cold (stone working) chisels down into the tube – the broad faces of the chisels against each other. This has the effect of both stretching the circumference and forming a rough rectangular shape. Once the circumference is large enough, a better rectangular shape is formed by squashing in a vice and hitting it with a small hammer. The above stages are repeated until the end will fit into, and just through, a WG16 flange. A little persuasion with a small hammer may be needed to actually get the end of the tube right through to the far side of the flange.

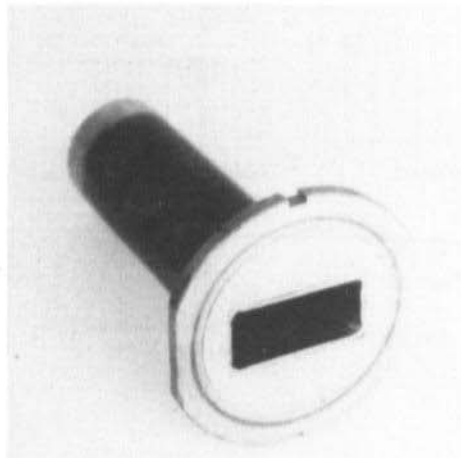


Fig. 3: TE10 to TE11 converter

Once the copper pipe has been forced through the flange, an old flat-ended file is used as a blunt chisel to form the copper close to the walls of the WG16 flange. This is especially required in the corners. The two chisels pushing against each other may also be able to achieve this, depending on their size.

Excess copper is then carefully filed off taking care not to damage the flange. The process is completed by rubbing the flange, with copper tube inserted, face down on a sheet of fine abrasive paper which is face up on a good flat surface.

The converter is now ready to be soldered. Normal soft solder was used as the solder is not in the path of RF. More than normal solder will probably be needed to ensure the joint is water proof if the converter is to be used outside. Once soldered the surface of the flange should again be cleaned with abrasive paper as described above. Finally a short length of tubing will have been damaged by clamping and hammering at the round end – this will need to be removed.

1.2. Jointing in TE11 Mode

Conventional 22 mm straight water pipe jointing sections may be used, provided care is taken when the joint is soldered. These sections sometimes come with solder rings already inside them but this type tends to have too much solder in them for our application and the excess tends to run out into the waveguide which adds to the

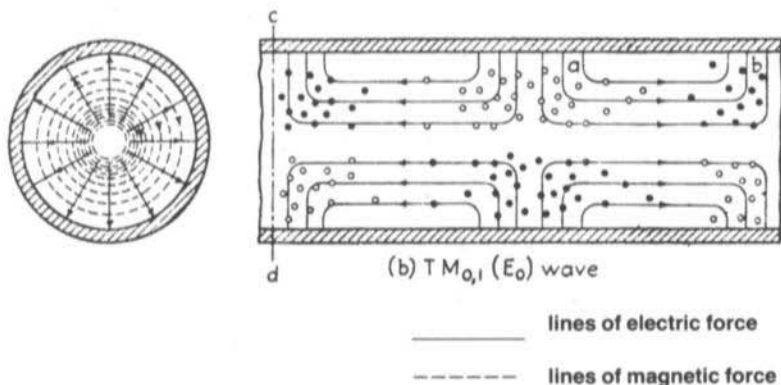
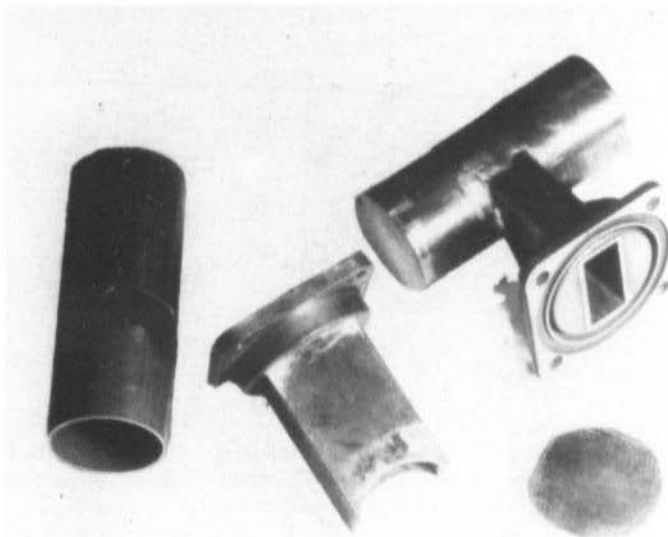
Fig. 4: TM_{01} mode in circular guide



Fig. 5:
TE10 to TM01 converter



waveguide losses. The type with no solder in is to be preferred. When soldering this latter type of joint, apply just enough solder to make the joint air-tight.

Slow 90 degree bends can also be used but the electric field will be rotated by this joint.

2. TM01 MODE IN CIRCULAR WAVEGUIDE

The disadvantage of using the TE11 mode described above is the somewhat un-predictable rotation of the electric field. However, by using the TM01 mode this particular problem is overcome. **Figure 4** shows how the electric and magnetic fields occupy the waveguide in TM01 mode. The advantage with this mode is that the electric field radiates from the centre to the inner surface of the tube; thus it is symmetrical about the centre axis (a bit like a coaxial cable) and orientation is insignificant. In order to propagate 10 GHz

in this mode, 26 mm id (28 mm od) copper tubing is used.

26 mm id tube in TM01 mode has the following characteristics: —

Cutoff frequency 8.8385 GHz
Cutoff wavelength 3.393 cm

The guide wavelength at 10.350 GHz is 5.56 cm. Formulae are given in Appendix 1.

There is one disadvantage in using TM01, namely that the mode of propagation does tend to revert back to TE11 if sharp bends or discontinuities are introduced into the waveguide. This can be understood if a sharp right angle bend is compared with the converter described below — the main difference being that the distance from the shorted end to the centre of the rectangular hole is zero.

2.1. Rectangular TE10 to Circular TM01 Converter

A photograph of this converter (1) is shown in **figure 5**. It is merely the intersection of WG16 and 26 mm id tube. The distance from the centre

of the rectangular hole in the copper tube to the inner surface of the shorted end is important, it should be three quarters of the TE11 wavelength. This puts a large series reactance for mode TE11 at the exit of the WG16 so this mode is not excited in the circular guide. The internal diameter (26 mm) is chosen to be approximately half the TM01 wavelength.

2.2. Circular TE11 to Circular TM01 Converter

This is very much like the converter described above except that the 20 mm id tube takes the place of the WG16. In fact a ready made plumbing "T" joint with 28 mm od along the top and 22 mm od down has been modified to act as a converter. However, the orientation of the electric field as it enters the 28 mm tube is important so a rotating joint of some description would be necessary.

2.3. TM01 Matching Sections

In rectangular guide operating in TE10 mode, the length of the guide can be electrically altered by inserting matching screws into the electric field from the broad face of the waveguide. However, this is not possible in circular mode TM01. Instead, a series of short sections of waveguide were made. The length increased in increments of 5 mm and ranged from 80 mm to 115 mm, including a joint at one end. These were then inserted in sequence into the system until the best match was found. (Fine adjustment can be made by not quite pushing the joint home.)

2.4. A Simple TM01 Slot Radiator in Circular Waveguide

A slot whose length approximates to half the wavelength in air will radiate if it traverses to an electric field. Therefore at 10.350 GHz a slot of length 14.5 mm around the circumference of the tube will radiate. (It is important to attenuate the signal to a safe intensity before taking measurements close to any radiator.) The matching section on the top of the antenna is tuned for maximum radiated or received power. In practice it has been found preferable to make matching sections rather than purchase the

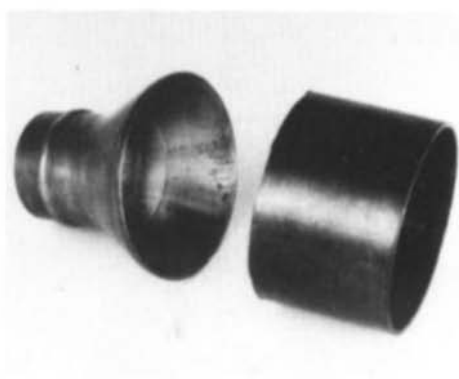


Fig. 6: A small horn antenna

plumbing part. To make one of these a standard straight joint is cut in half and then a brass disc is silver-soldered to one end.

2.5. A Small 26 mm Conical Horn Antenna

A straight plumbing joint which allows a pipe of 28 mm od to join a pipe of 52 mm od was successfully modified to work as a horn. Figure 6 shows a photograph of the joint just after it was cut with a hack saw. The only modification was to remove all of the 52 mm pipe and bevel the outer edge of the resulting conical horn, as is shown in the photograph.

2.6. A TM01 to 'N' Type Transition

Figure 7 shows a TM01 to 'N' type transition. A brass disc is first drilled to take the 'N' type chassis-mounting socket and then the disc is silver-soldered to the copper tube. A short length of 6BA studding is then screwed into a 6BA brass hexagonal pillar and silver-soldered into place. This merely blanks off one end of the pillar. The length of the pillar is then adjusted to the dimensions shown in figure 7. The open end of the pillar is finally drilled out to be a tight fit with the 'N' socket and then soft-soldered onto the 'N' type connector.

The length of the inner piston has been adjusted experimentally to yield approximately 50 Ω at 10.350 GHz. Regrettably lack of test equipment made it impossible to improve on this design.



3. USEFUL HINTS

3.1. Preparation of Copper Tube

The author has learnt by experience that it is best to see and select the length of tube rather than be handed a length over the counter. Tubes sometimes contain grease and other dirt which is very difficult to clean out, and occasionally they have a few minor dents. All tubing should be cleaned as thoroughly as possible before use.

Cleaning can be carried out by pushing a cork in one end, pouring a good solvent into the tube, followed by small pieces of metal such as nuts or ball bearings, and then placing a cork in the

other end. The tube is then rotated end over end for a few minutes, preferable outdoors in case one of the corks drops out!

3.2. Useful Tools

Plumbers use a tool known as a pipe cutter. This tool cuts all pipe sizes in the range 6 mm to 28 mm. In the UK the price of these range from about £10 to £20 but if a significant amount of tube work is to be undertaken, the purchase of one of these is recommended as cutting a pipe takes seconds and the cut is perpendicular. Their principle of operation is that a cutting edge is rotated accurately around the outside of the tube several times and eventually cuts through it. The inner edge usually needs a little deburring after cutting. This is either performed with the

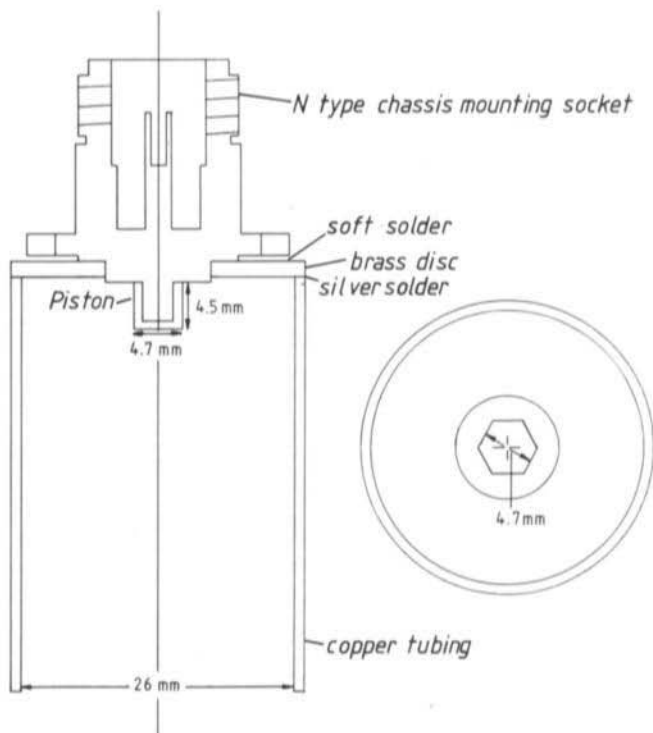


Fig. 7: TM01 to 'N' type transition



blunt knife often attached to the pipe cutter or a round file. The pipe cutter may also be used to scribe a line around the circumference of the tube prior to filing slots etc.

A cheap oxygen torch has been found invaluable for silver-soldering, experience having shown that some blow-lamps will not quite attain a high enough temperature.

3.3. Acknowledgements

I would like to thank G 3 VMW, GW Ø FJV and G 8 MXI for their help during this project.

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Microwave antenna theory and design.
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Radiation Laboratory Series No. 12) p. 308
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5. APPENDIX I

5.1. Rectangular Guides

a = transverse dimension of guide, x dimension.

b = transverse dimension of guide, y dimension.

f = frequency, in Hz.

$\omega = 2\pi f$, angular velocity, radians per sec.

β = phase constant, radians per cm, based on phase velocity.

λ = wave length, cm (in free space).

c = velocity of light, 3×10^{10} cm per sec.

Operating Characteristics Common to All Rectangular Modes

Wave length in guide:

$$\lambda_g = 2\pi/\beta$$

Wave length in free space:

$$\lambda = c/f$$

Phase velocity:

$$v_p = \omega/\beta$$

Group velocity:

$$v_g = d\omega/d\beta = c^2/v_p$$

Mode	Cutoff frequency, f_0	Cutoff wave length, λ_0	Phase constant, β
TE _{1,0} (H _{1,0})	$c/2b$	$2b$	$\frac{2\pi}{\lambda} \left[1 - \left(\frac{\lambda}{2b} \right)^2 \right]^{1/2}$



5.2. Circular Guides

a = guide radius, cm.

f = frequency, in Hz.

$\omega = 2\pi f$, angular velocity, radians per sec.

β = phase constant, radians per cm, based on phase velocity.

λ = wave length, cm (in free space).

c = velocity of light, 3×10^{10} cm per sec.

Operating Characteristics Common to All Cylindrical Modes

Wave length in guide:

$$\lambda_g = 2\pi/\beta$$

Wave length in free space:

$$\lambda = c/f$$

Phase velocity:

$$v_p = \omega/\beta$$

Group velocity:

$$v_g = d\omega/d\beta = \frac{c^2}{v_p}$$

Mode	Cutoff frequency, f_o	Cutoff wave length, λ_o	Phase constant, β
$TM_{0,1} (E_0)$	$0.383 \frac{c}{a}$	$2.61a$	$\left[\left(\frac{2\pi}{\lambda} \right)^2 - \left(\frac{2.405}{a} \right)^2 \right]^{1/2}$
$TE_{1,1} (H_1)$	$0.289 \frac{c}{a}$	$3.46a$	$\left[\left(\frac{2\pi}{\lambda} \right)^2 - \left(\frac{1.84}{a} \right)^2 \right]^{1/2}$



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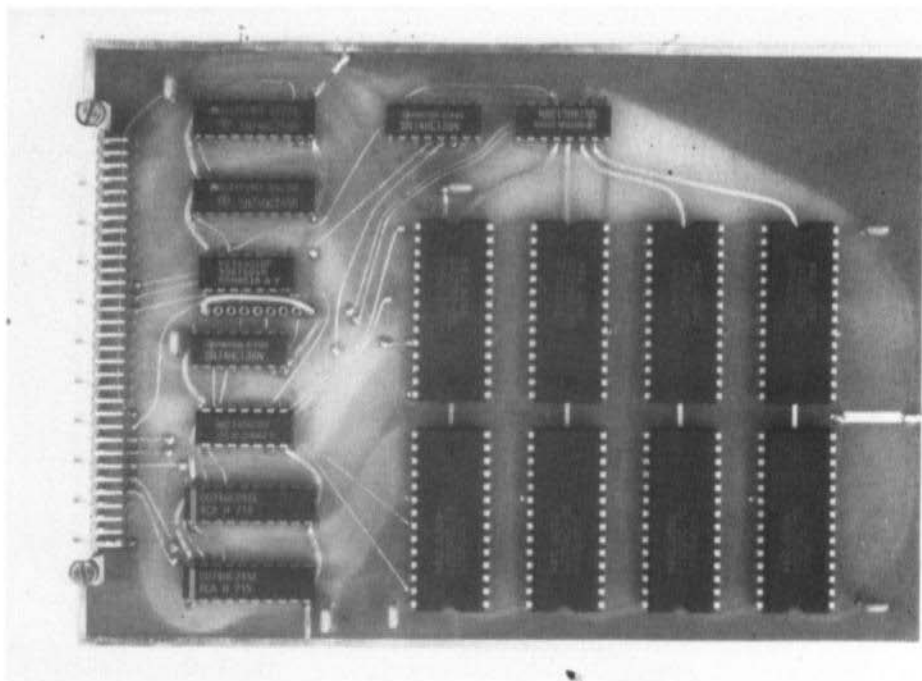


Fig. 3.8.: One of the four CMOS memory boards in the computer (top middle: the address selection)

The bus board (YT 3 MV 003) only includes 8 female "Eurocard" connectors and supply 9 bypass capacitors. The location of the latter is shown in **figs. 3.1. and 3.2.** The board itself is made of 2.5 mm thick laminate for mechanical strength. The connector pins should be 4 mm long for easy soldering. The connectors are held in place with two 8 mm long M3 screws. It is very important to install these screws first, before soldering the pins, otherwise the sensitive springs inside the female connectors will be damaged resulting in intermittent contacts!

The power supply is built on a single-sided printed circuit board (YT 3 MV 009) 120 mm long and 100 mm wide (**figs. 3.13. and 3.14.**). Since it includes a few heavier components, like the NiCd batteries or the ferrite pot core and requires a few connections, only 4 wires, with the computer bus, the unit is not equipped with an "Euro-

card" connector. It is to be installed separately using four M3 screws in the corners.

All electrolytic capacitors are vertical types (see **fig. 3.14.**). The NiCd cells are installed horizontally. The connections are made by soldering two pieces of 1 mm thick copper wire to each battery cell terminals which also keep the cell in place. The BDX34 power darlington transistor is installed on a small heat sink with an M3 screw.

The (approximately) 10 μ H/5 A chokes include 25 turns of 1 mm thick enamelled copper wire wound on a 5 mm diameter ferrite screw. The storage coil L is wound on a 30 mm diameter pot core with an approximately 0.5 mm thick air gap. It has 10 turns of four times 0.5 mm enamelled copper wire.

The rotator interface board (YT 3 MV 010), shown in **figs. 3.15. and 3.16.**, is a stand-alone board

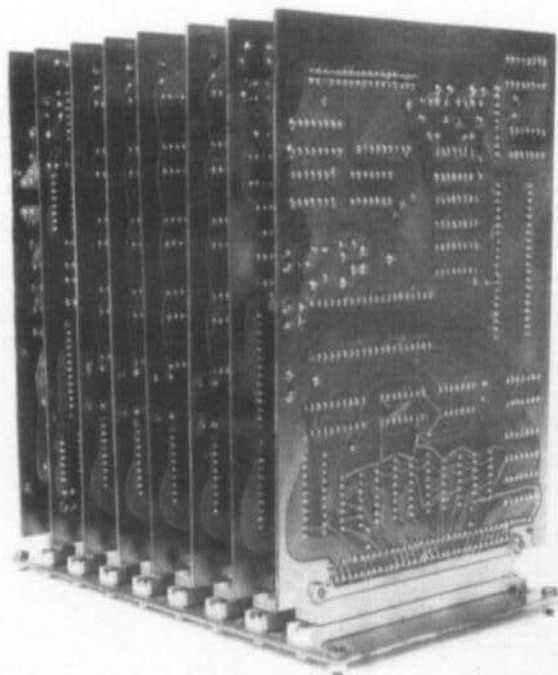


Fig. 3.2.:
The bus board with
all 8 units

and also depends on the clock waveform. The best results were obtained with a Valvo 74HC00 as the clock oscillator.

The video board uses special dual-port memories. In the prototypes I successfully tested both μ PD41264 (NEC) and HM53461 (Hitachi) with identical results. Both 120 ns and 150 ns selections worked at 10 MHz CPU clock. The 120 ns version is of course recommended for higher CPU clock frequencies. No problems were ever noticed using a refresh rate of 20 ms (TV frame) in place of the 4 ms recommended by the manufacturers. The DAC0800 D/A converter is available from many suppliers.

The main computer memory uses static CMOS memories. Over 120 NEC μ PD43256 120 ns chips were tested without problems. The memory boards also worked with similar memories from other manufacturers. For processor clock fre-

quencies above 10 MHz 100 ns access time memories are recommended.

The NEC 710xx series peripherals are CMOS versions of the famous 82xx series of micro-processor peripherals. The μ PD71055 parallel I/O port on the processor board can be replaced with a NMOS 8255, the latter sometimes requires a 330 pF capacitor to delay the \overline{CS} signal for proper operation. The μ PD71054 programmable counter can be straightforward replaced with a 8253 chip. On the other hand, the μ PD71051 USART can not be replaced with a NMOS 8251, since the latter is unable to operate at a 6.144 MHz clock frequency. A 82C51 could work, but was not tested. The μ PD4990 real-time calender/clock chip is also manufactured by NEC.

Suitable CODEC chips are manufactured by Mostek: MK5156 and by SGS: M5156. The SGS



All the software was designed for a minimum clock frequency of 9 MHz, but a higher clock frequency is very desirable.

The remaining modules are easy to test once the processor is operating, since the latter can also be used as a powerful troubleshooting tool. The easiest to test are the memory modules. When installing the memory modules do not forget to program each of them for a different address range. Further, all the modules should form a contiguous memory area to be used efficiently by the operating system software.

To test a memory module, try the "W" instruction first to write to or read from a few memory locations. Most defects are discovered in this way. However, it is a little impractical to test 1 Mbyte of memory in this way. The final check can be done later, for instance by loading a few files from a floppy disk.

The analog I/O board first requires a few checks on its own. The on-board voltage inverter should supply a negative voltage of -5 V. The crystal oscillator has to be adjusted exactly to 6.144 MHz with a frequency counter only connected after a buffer gate. If it is not possible to adjust the frequency with the given tuning range of the trimmer capacitor, then the fixed capacitor in parallel with the trimmer should be replaced.

The operating system software does only include routines to use the RS-232 port on the same module. The analog I/O could be tested issuing a number of "W" commands to initialize the appropriate registers, but it is usually easier to load a DSP program that uses the analog I/O port. The A/D converter offset can be adjusted when running a program that is sensitive to A/D offset errors, like the APT picture receiving program.

Before installing the floppy disk controller module, the floppy disk drive manual has to be consulted. All the connections between the drive and the controller should be verified and the jumpers adjusted for the drive used.

The floppy controller itself requires three adjustments: VCO frequency, read pulse width and write precompensation. All three adjustments are to be performed by connecting the TEST input (pin 22) to GND only AFTER reset has been applied to the computer. Grounding TEST while

reset is active will program the 2797 FDC for a different mode of operation! The divided VCO frequency, 250 kHz, can be measured on pin 16 (DIRC) with a frequency counter and adjusted with the VCO's capacitive trimmer. Then the RPW duty cycle can be observed with an oscilloscope on pin 29 (TG43) and has to be set to 12.5% using the 47 k Ω trimmer.

The write precompensation pulse width can be observed on pin 31 (WD). Since however the floppy drive manuals seldom specify this value, an experimental adjustment is required. Leave the 10 k Ω trimmer in center position and disconnect the TEST line from GND. Insert a new, empty floppy disk and try to format it as described in the operating system manual. An improper write precompensation will result in formatting errors appearing on the innermost tracks, usually on tracks 75 to 79. In the case of errors, try another setting of the 10 k Ω trimmer and retry formatting tracks 75 to 79 until all the tracks format properly.

The rotator interface only carries a single trimmer. However, there are two trimmers in the rotator control unit and eight variables in the tracking program to be adjusted. All these adjustments are to be made with the actual rotator with the antennas installed. To understand all these adjustments an insight in the operation of the automatic tracking program is required.

3.5. HOUSING CONSTRAINTS

After assembly, the completed computer has to be installed in a suitable case. There are, however, mechanical, thermal and electrical constraints. The main mechanical requirement is to build a suitable guide structure to keep the modules in their respective connectors. Also when the computer is being transported to another location, it is very inconvenient if all the memory content is lost due to an intermittent contact on the bus.

The electrical performances of all integrated circuits used in the computer degrade quickly

and a negative-going strobe. A keyboard that only requires a + 5 V supply is preferred.

The 3.5" floppy drive should be suitable for double-sided 80 track floppies. The spindle motor speed should be 300 rpm. The raw capacity is 1 Mbyte at 250 kbps MFM. I successfully tested three different floppy drives: NEC FD1036 and FD1037 and Matsushita JU363. Older models, like the FD1036 or the JU363, require two supply voltages, + 5 V and + 12 V. New models, like the FD1037, operate from a single + 5 V supply but do not provide a READY signal (move the corresponding jumper on the floppy controller board). Warning! Although all three floppy drives use the same 34 pole connector, the connections on one drive were found to be a "mirror image" of another drive!

The video board will drive any (European) standard TV monitor. Only the vertical sync and

size may need to be adjusted to the slightly different frame frequency. Due to the resolution of the picture displayed, a 12" or larger screen is recommended. If possible, the monitor should be installed in a metal case to avoid interferences to sensitive communications receivers.

3.3. INSTALLATION OF COMPONENTS

The processor board, the video board, the memory, the analog I/O and floppy controller are all built on double-sided printed circuit boards, 170 mm long and 120 mm wide. All modules have a 64 pole "Eurocard" male right-angle connector with rows A and C equipped with pins and row B empty. The diameters of the two mounting holes

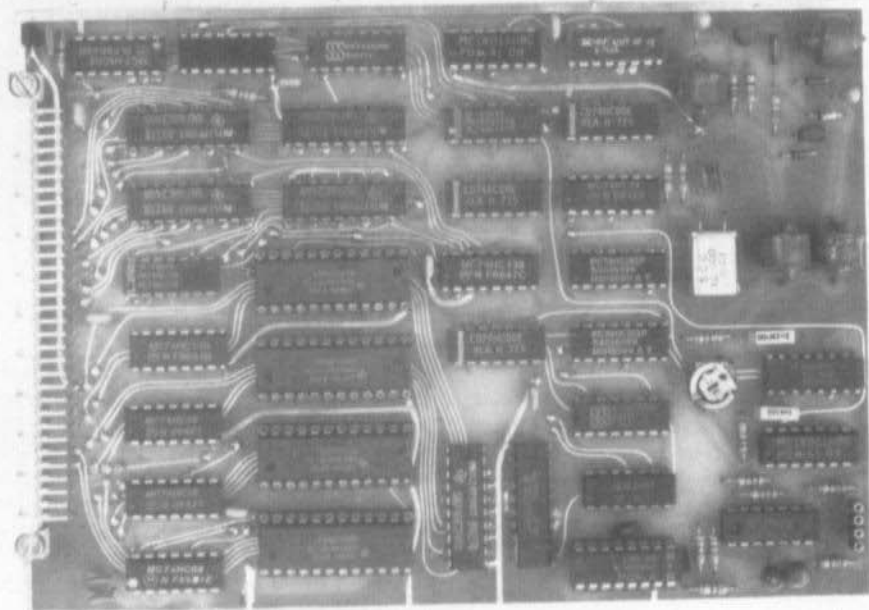


Fig. 3.6.: A ready-made video board (the chokes come from old TVs)

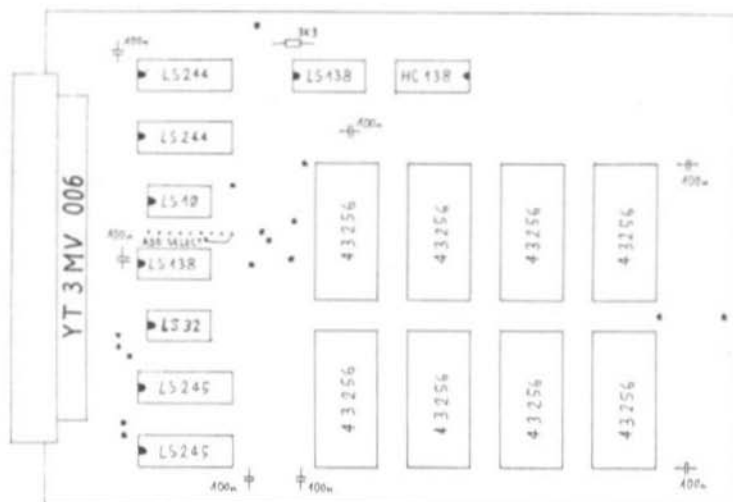


Fig. 3.7.:
Component location
plan of the 256 k CMOS
memory board
YT3MV 006

on each connector have to be slightly enlarged to accept two 10 mm long M3 screws to hold the connector in place on the printed circuit board.

The detailed component location plans of the above modules and the belonging photographs to it are shown in **figs. 3.1. to 3.16.** respectively. * Symbols denote feedthrough holes: no component leads are installed in these holes, their only purpose is to connect traces on different sides of the printed circuit board.

All integrated circuits can be installed on (good quality) sockets. Use the type with round lathed contacts with gold-plated springs inside. For eventual troubleshooting it is only important to have the complex function ICs on sockets, like the microprocessor or peripherals, it does not help much to have all the TTLs or 40xx series CMOS on sockets.

All integrated circuits used in the DSP computer may be damaged by electrostatic discharges. While CMOS and NMOS circuits have protection networks to reduce the probability of damage, new bipolar circuits with small geometries are also sensitive to static discharges. The best way to prevent these problems is to understand the damage mechanism. A certain amount of energy is required to destroy an integrated

circuit. Since the induced electrostatic voltage is limited by effects like corona discharge, the only variable left is the capacity of the capacitor holding the charge. For example, simply touching a pin of an unconnected IC can never be harmful: the capacity of the relatively small IC package towards its surroundings is very small. On the other hand, if the IC is installed in a circuit and the circuit is grounded or connected to another high capacity object, the energy may be sufficient to destroy a bipolar TTL IC. Therefore, I do not recommend using conductive ground planes for working surfaces or grounding wrist straps since in the case of a mistake, the latter may be dangerous for the operator too. Simply avoiding "dangerous" situations, like a high capacity to high-capacity discharge through a sensitive component like the one described above, I never had even a single failure of a MOS IC to be attributed to a static discharge!

IC sockets are also used as jumper plugs (to select the interrupts) and as connectors. A very simple but reliable connector joint can be built from two identical IC sockets. One socket is soldered into the printed circuit board and is used as a female connector. The other socket is used as a male connector with wires soldered in the holes for the IC pins.



Matjaž Vidmar, YT 3 MV

Digital Signal Processing Techniques for Radio Amateurs

Part 3: Construction and Use of the DSP Computer

In this announced third part of the DSP series, the construction of the computer, described in part 2 (VHF COMMUNICATIONS 1/1989), will be made possible. This powerful computer can be used for many applications, however, its speciality is Digital Signal Processing, as described in part 1 (VHF COMMUNICATIONS 2/1988). Part 4 will be concentrating upon the application software.

3.1. CONSTRUCTION OVERVIEW

Although Digital Signal Processing was introduced to simplify the hardware required and thus reduce costs, some hardware still has to be built. Assembling a computer-type circuit is certainly not as demanding as building a radio-frequency analog circuit, especially not from ready-made building blocks, like microprocessors, peripherals or memories.

However, these ready-made building blocks do not always conform to the published specifications, especially when there are more manufacturers offering apparently interchangeable products. Even with products from the same

manufacturer there are sometimes sudden changes due to a new manufacturing process or simply a spread of important parameters well in excess of what is guaranteed in the data sheets. During circuit design, every effort was made to try as many different products as possible and the results are presented as a recommended "component selection".

After assembly, the single modules have to be checked for correct operation. Some modules may require a few alignments of the on-board trimmers. Then the complete circuit has to be installed into a suitable case. To help correctly choose the latter, the mechanical, thermal and electrical constraints will be discussed.

Installing the software includes the adjustment of the various parameters to other analog hardware available, like transmitter modulation levels or packet-radio delays. Since source files will be made available, it is also possible to "personalize" the software adding minor but important features.

A few hints how to write DSP software are also described in this article. However, most users will probably find it necessary to refer to literature describing the microprocessor and peripherals used. Unfortunately there is not much literature discussing DSP techniques on an amateur level yet. Hopefully this will change in the near future.



3.2. SELECTION OF COMPONENTS

Throughout the DSP computer design and development I tried to use readily available components. Overall cost was also an important consideration.

Most computer components are integrated circuits, either complex function blocks like the microprocessor or memories, or simple TTL and CMOS SSI gates and flip-flops. The latter belong essentially to three logic families. The bipolar LS (Low-power-Schottky) series is used for most functions. The new HC CMOS series is used where both speed and low-power drain in standby are required. The old 40xx CMOS series is used where speed is not critical. Finally, there are also a few ICs from other logic families where required.

Considering the decreasing prices of the HC family it is already convenient to replace the old LS series with the better HC series. If all LSs are changed to HCs, no additional pull-up resistors are required and many 3.3 k Ω pull-up resistors

can be omitted. In fact, prototypes built with all HC circuits operated better than those with LS circuits. HC ICs have a higher noise margin and a stable output impedance compared to the LS series: both contribute to suppress crosstalk and ringing of the computer bus. An "all HC" design is recommended for CPU clock frequencies above 10 MHz.

The 68010 microprocessor is manufactured by Motorola, Signetics, Thomson-CSF, Mostek and probably some other manufacturers. The MC 68010 is usually available selected according to the maximum guaranteed clock frequency of 8 MHz, 10 MHz and 12.5 MHz. I only had available 11 samples from Motorola with different specified clock frequencies, different packages and different manufacturing dates and mask-set identifiers. In practice I noticed a very large spread of the maximum clock frequency: guaranteed 10 MHz samples reached from 9.5 MHz up to 15 MHz before crashing the software. For comparison, the 8 MHz sample reached 12.5 MHz and the 12.5 MHz sample reached 14.5 MHz. Some experimenting may therefore be very worthwhile! The maximum clock frequency decreases quickly with increasing chip temperature

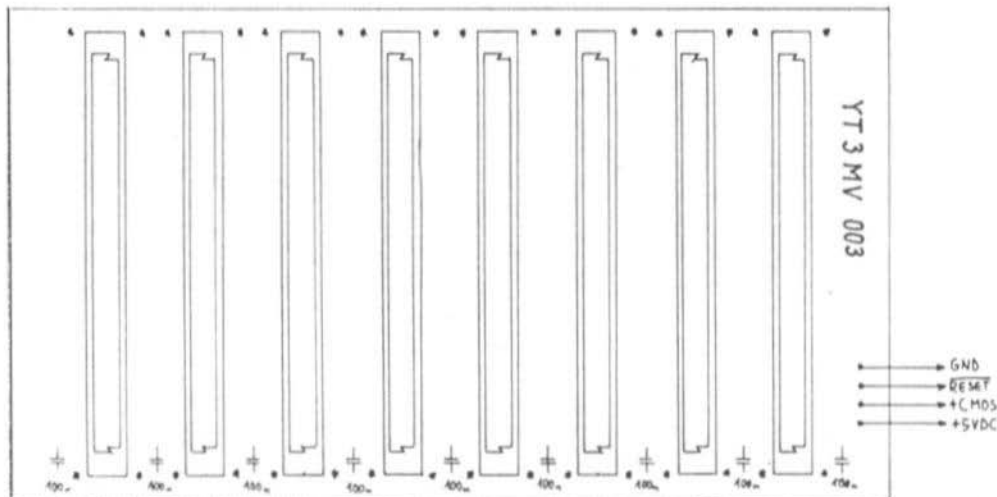


Fig. 3.1.: Component location plan of the YT3MV 003 bus board



but otherwise the installation of the components is identical to other computer modules. If all the integrated circuits used are CMOS versions as recommended, then the power drain is so low that the 7805 regulator does not require a heat sink.

3.4. MODULE CHECKOUT AND ALIGNMENT

It is not recommended to assemble the complete computer with all the modules and apply the supply voltage. With such a complex circuit chances that everything will work immediately are very small. Further, a malfunction in one of the modules, especially the power supply, could damage many expensive components on other modules. Finally, troubleshooting may be impossible in these conditions.

After assembling the single modules, an accurate visual inspection of the printed circuit boards is highly recommended. My personal experience is that most mistakes are made during soldering: either missed connections or accidental shorts between adjacent lines. After this the modules should be checked in a reasonable order – using already tested modules to check another module.

The first module to be tested is obviously the power supply. Its input should be connected to an adjustable voltage DC source to test both the switching regulator and the reset circuit. Due to manufacturing tolerances of zener diodes it may be necessary to change the nominally 820 Ω resistor (*) in series with the zener diode to obtain the correct output voltage of 5 V (under load!).

The reset circuit should have the required hysteresis and delay. The voltage across the NiCd battery should also be verified. Finally, the 1N5822 schottky diode, used to charge the battery, should be verified for leakage current (main power off). It should not be more than 20 μ A measuring the voltage fall across the 120 Ω resistor. Do not unsolder the diode just for measuring purposes since the leakage current is

very temperature dependent.

Next, the bus mother board has to be checked. The latter has a very large number of close solder joints. It is recommended to test it with an ohmmeter for shorts before connecting the four wires to the power supply.

Whenever inserting modules in the bus board, keep in mind that some supply voltages are always present, even with the main power off, due to the NiCd battery. The best way to insert a module with an "Eurocard" connector is to make the ground connection first. Since the latter is on the opposite side of the supply contacts, it is sufficient to remember to always plug-in the modules under such an angle that the ground connection is made first. Before plugging-in a module, a static discharge, touching both circuit grounds at the same time with naked hands is recommended too.

The video board can now be plugged into the bus. Connect a TV monitor to the video output. Due to the random content of the dynamic RAMs after power-up, the video board should produce a rectangle containing a random pattern and surrounded by a black border on the TV screen. Adjust the horizontal position trimmer to center the picture. Also adjust the various controls on the TV monitor to obtain a reasonable quality TV picture. Also check the operation of the on-board flyback inverter, which should produce a negative supply voltage of about - 4 V.

Once the video board is working, the processor board can be added. Of course turn the power off before plugging in or out any module! Do not connect a keyboard to the processor board, nor the partial/total reset switch. The latter connection should be left open to enable a total reset. If everything is working properly, the random pattern on the TV monitor should disappear about one second after power-up (reset delay) and be replaced by a help message text covering almost all the screen. A blinking cursor should also appear.

If the random pattern remains unchanged, there is a problem on the processor board or on the video board that has to be repaired before you can proceed with other modules. In this case it is useful to check the behaviour of the HALT line on

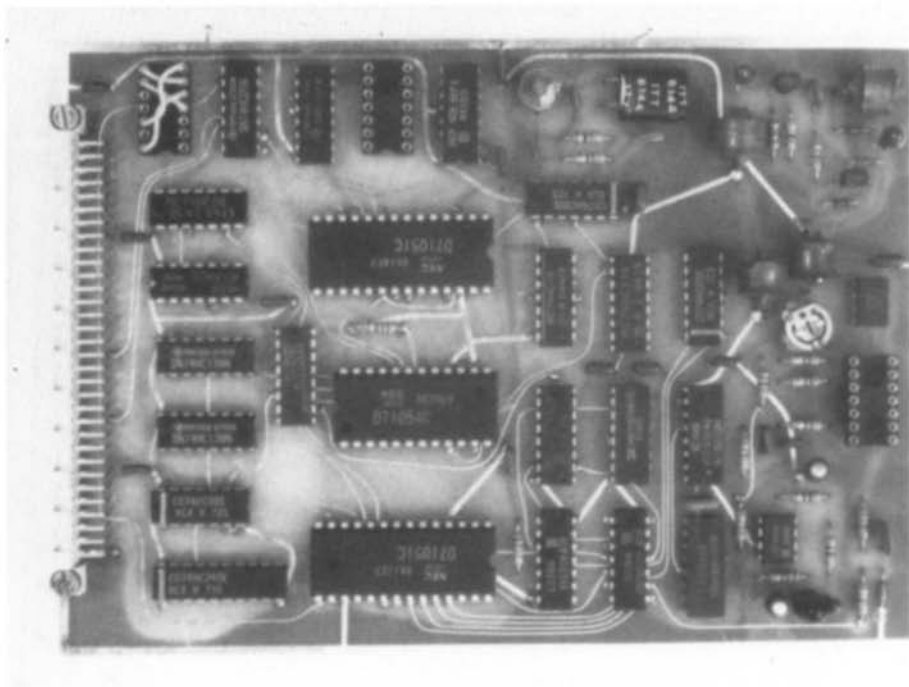


Fig. 3.10.: Prototype of an YT3MV 007 analog I/O board

the bus — a double bus error makes it go low. Please remember that for a correct start-up, the software required is contained in the 27128 (or 27C256) EPROM. The operation can not be checked without a programmed EPROM!

When the processor board is working correctly the keyboard can be connected. Under the operating system command mode, all the printable characters should be printed on the screen up to the maximum allowed line length. Any control character is interpreted as a carriage return. Any letters will only be printed in upper case in the command mode. The code required for the delete function is 7FH. After this, try to issue some simple commands as described in the operating system manual. Avoid commands that use peripherals that are not installed yet, like the floppy disk or the RS-232 port.

The operation of the real-time calendar/clock

can be checked using the corresponding operating system command "U". It is a little more difficult to adjust the 32.768 kHz crystal to the correct frequency, since the oscillator circuit is a very high impedance circuit. The simplest way is to leave the trimmer in the middle position and correct the adjustment if a clock drift is detected a few days later.

The processor board carries a nominally 10 MHz crystal oscillator and the MC 68010 should also be a 10 MHz version. However, it is very useful to test your processor for its maximum speed. This can simply be done by replacing the crystal in the clock oscillator. Of course, the computer can not be operated reliably at the maximum clock frequency. The latter will be further reduced when loading the bus with additional modules. A safety margin of about 2 MHz below the maximum frequency was found appropriate in most occasions.

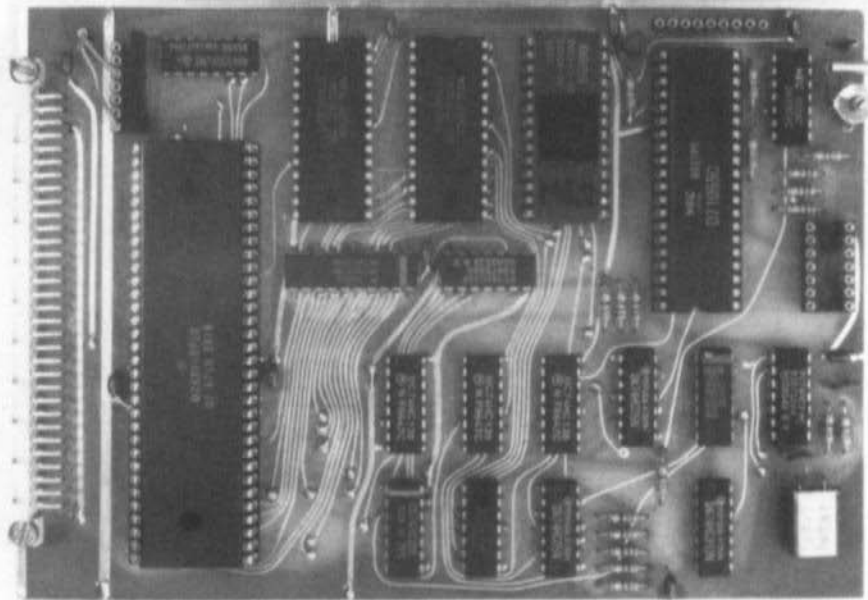


Fig. 3.4.: Prototype of a CPU board with an elder EPROM

samples had a lower DC offset in the A/D section than the Mostek parts. No differences were noted between the switched capacitor filters manufactured by National Semiconductor: TP3040 and its Thomson-CSF equivalent: ETC5040.

The floppy disk controller IC is manufactured by Western Digital: WD2797 and by Siemens: SAB2797. The serial communications controller is available from Zilog: Z8530 and from Sharp: LH8530. The same companies also manufacture a CMOS Z80CPU (used in the rotator interface) marked Z84C00 and LH5080 respectively. The ADC0804 is manufactured by National Semiconductor and equivalents are available from other manufacturers too. For accurate tracking it is recommended to use the more accurate versions of the same chip, marked ADC0802 or ADC0801.

The computer modules include many crystal oscillators. Only two oscillators really need to be accurate and have trimmers for fine frequency correction: the real-time clock chip with a 32.768 kHz crystal and the 6144 kHz crystal on the analog I/O board that defines the sampling rates. Both these crystals are fundamental mode, 20 pF parallel resonance. All the remaining crystal oscillators at 10 MHz (CPU), 12 MHz (video), 16 MHz (FDC), 6.144 MHz (serial I/O) and 10 MHz (rotator interface) need not be very accurate. "Computer-grade" fundamental mode crystals are adequate and no fine adjustment trimmers are provided.

Finally, the computer also requires a few larger units: a keyboard, a floppy drive and a TV monitor. The keyboard should be a standard ASCII keyboard with a parallel output including 7 data bits

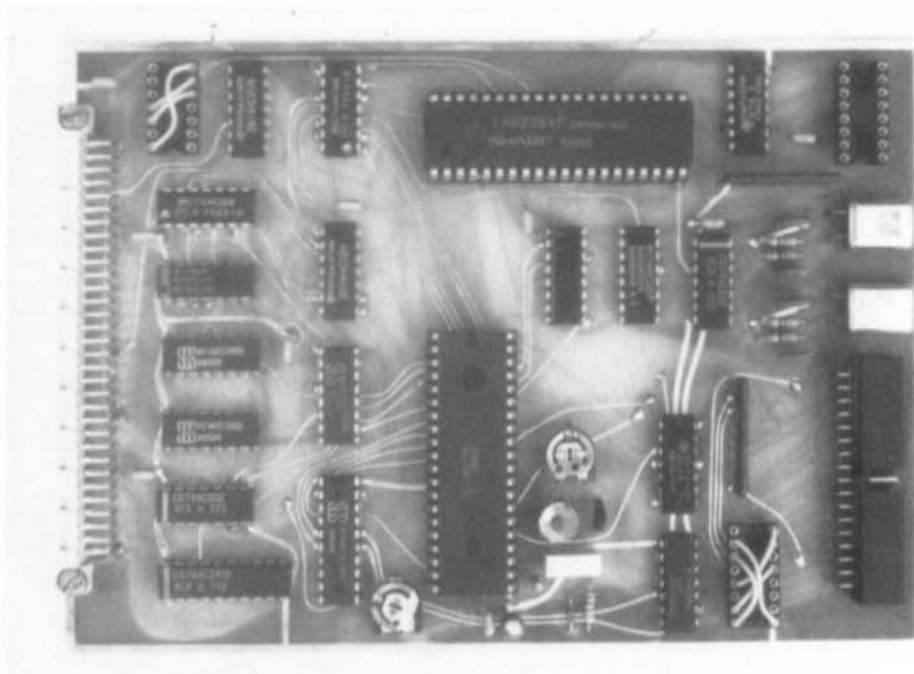


Fig. 3.12.: Prototype of the YT3MV 008 serial I/O floppy interface

with increasing ambient temperature. In particular, the operating speeds of all logic families decrease with temperature. It is therefore highly desirable to keep the ambient temperature and the temperatures of the single chips as low as practical.

It is very difficult to install heat sinks on all integrated circuits. The printed circuit boards can, however, be installed in a vertical position to allow an efficient air flow. Finally, the power supply unit (another heat source) should not be installed close to the processor board (the most sensitive to heat).

A 16 bit microcomputer has at least twice the number of connections compared to an 8 bit microcomputer. A 16 bit computer also operates at a speed an order of magnitude faster than an 8 bit machine. The most immediate result is that a 16 bit microcomputer radiates 20 to 30 dB

stronger radio interferences when compared to an 8 bit microcomputer. Since a DSP computer is designed to work with communications equipment including sensitive receivers, a very accurate shielding is absolutely necessary.

The computer has to be installed in a metal (aluminium) box. It is important that the box is completely closed and that the covers make good electrical contacts with the box frame on all edges. The latter should therefore not be painted or anodized. All the connections should be bypassed and/or should use shielded cables. Bypass capacitors should be installed immediately on the connectors and ground conductors should be grounded on the connectors too, otherwise they will work as coupling loops for the disturbs. The keyboard connections, the video output, the RS-232 port and the high-speed serial port can not have bypass capacitors and the use of shielded cables is mandatory.



ASCII keyboards now use a single-chip micro-computer to scan the keys and generate the codes. The latter could also cause some radio frequency interference since keyboards are usually packaged in non-conductive plastic cases, although the switching frequency is low and the disturb level is low too. A metal-case keyboard is the best solution. A valid alternative is an old, surplus keyboard, with a dumb diode matrix logic, which can not generate RFI either.

A more important source of interferences is the TV monitor, if packaged in a plastic case. It will generally only cause interference when fed with a computer-generated video signal. The latter is amplified to about 20 to 30 Vpp to drive the CRT. A very efficient but cheap solution to limit interferences at VHF and higher frequencies is to filter the video signal before sending it to the TV monitor. Since the video signal does not contain useful information above 10 MHz, the spectrum above 10 MHz can simply be filtered away with a low-pass filter greatly reducing the interference without degrading the picture at all.

3.6. SOFTWARE INSTALLATION

Software installation is relatively simple compared to commercial computers. The operating system is completely contained in an EPROM. The actual version V7.1 is about 15 kbytes long and was written directly in MC68010 machine code. The EPROM can be a 27128 or a 27C256 programmed to fit in the same socket without modifications, since the 27128 and in particular the 27C128 are more expensive and not always available. For future upgrades, the CPU printed circuit board already carries an additional address line to three solder pads close to the EPROM socket. The circuit can be thus modified to use all the 32 kbytes of a 27C256. Note, however, that the 27C256 EPROMs supplied with the V7.1 software are programmed to fit into an unmodified circuit (A14 always high) and will not work if this modification is made.

After power-up the action taken by the computer

depends on the position of the partial/total reset switch, which should be installed on the front panel. In the case of a first power-up (or after a catastrophic software crash...) the computer requires a total reset. During a total reset, the whole content of the EPROM is copied into the nonvolatile system RAM. All system variables are thus reset to their default values. The operating system software is always executed in the RAM, since the latter has a much lower access time than the EPROM and does not introduce any wait states.

The partial/total reset switch is then moved to the partial reset position for normal operation. In this case the computer assumes the RAM already contains valid software and only a small part of the content of the EPROM is copied into the corresponding part of the RAM. Most of the software in the RAM is left unchanged including the operating system parameters.

After a total reset, some operating system parameters should be set. The most important is to tell the computer the location and amount of RAM available using the operating system command "N". This and other operating system commands are described in detail in the "Operating System Manual". The latter can not be published since it is too long but will be made available separately. A short description of all available commands can be obtained by issuing the "H" (Help) command. The latter is also programmed as the default autostart command.

Application programs are supplied on floppy disks. Both source program files and compiled executable files are usually made available. Application programs have extensive menus and/or help messages activated only when a wrong command is issued. To use a program, it is only necessary to load the compiled (.EXE) file from the floppy disk into the RAM (command "L"). A program can then be executed using the command "R".

DSP programs contain many variables – parameters to be set by the user. In the supplied application programs these variables have been set according to my own analog hardware. Some programs also include an option in the main menu to reset all variables to their default values.

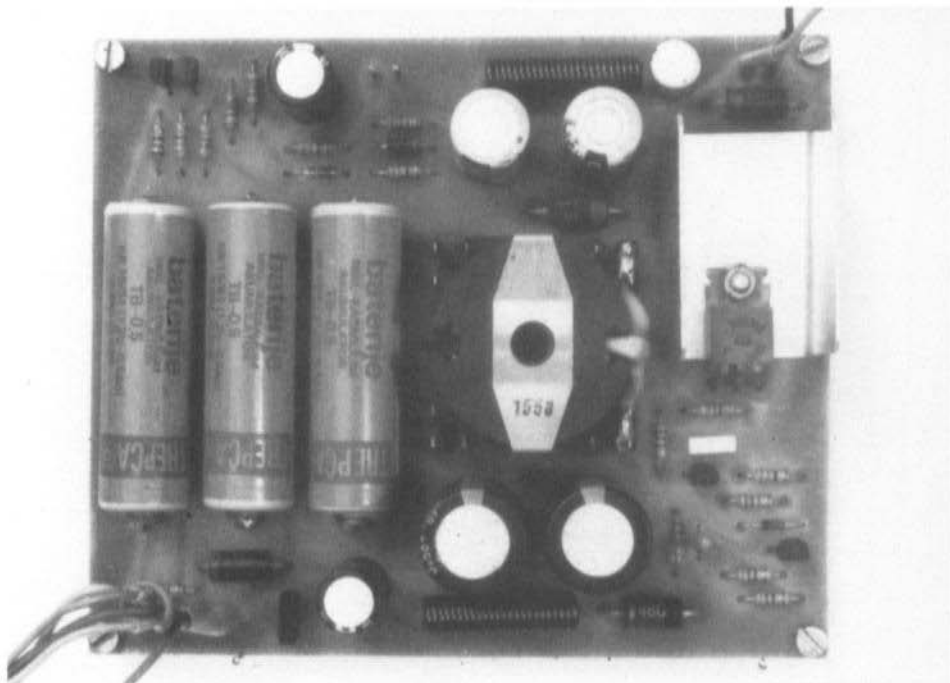


Fig. 3.14.: Power supply YT3MV 009

try to copy all variable values into the new executable file. This is very useful since, for example, after a small modification of the satellite tracking program it is not necessary to type in the Keplerian elements for 40 satellites again (only a few hours of typing...).

Finally, if an application program tries to use an inexistent peripheral or runs out of memory, the operating system will stop the execution in an orderly way indicating the bus error address, type of access and program counter value.

3.7. WRITING DSP SOFTWARE

DSP programming usually includes both programming in machine code for the DSP algorithm

itself and programming in a high-level language to support and use the DSP routines. To recall the DSP routines periodically, interrupts have to be used. The following discussion describes how this can be done efficiently on the DSP computer described.

When a MC68010 microprocessor receives an interrupt request with a priority level higher than the current processor priority (described with the corresponding bits in the status register), a call to the interrupt handling routine is made. Start addresses of interrupt handling routines are stored together with other exception vectors in the exception vector table in the computer memory. The exception vector table is located in the system RAM during normal program execution (except at power-up). Its start address is stored in the Vector Base Register (VBR).

Hardwired logic on the processor board makes the MC68010 to operate in the autovector mode:

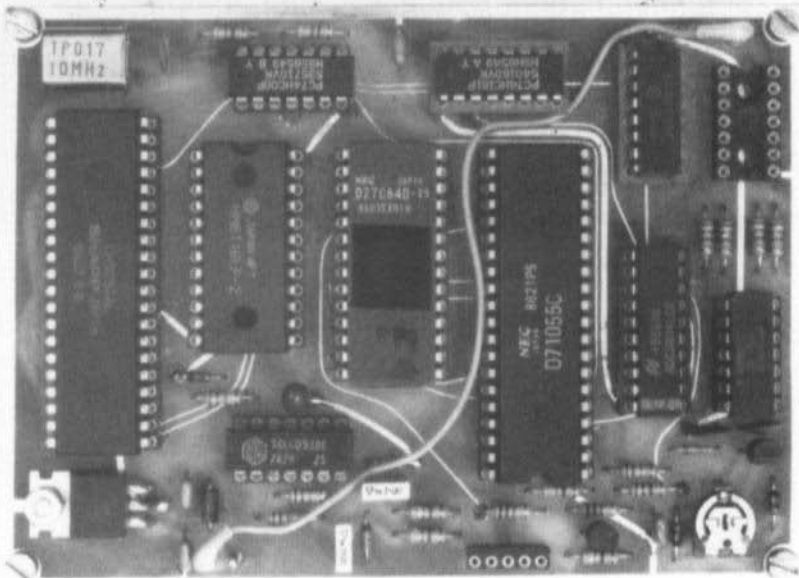


Fig. 3.15.: Component location plan of the YT3MV 010 KR-5600 rotator interface

each interrupt level is assigned a single vector in the exception vector table. After reset, all interrupt vectors are pointing to an error handling routine (except interrupt 7 – the operator keyboard) and the processor priority is set to 7. To use an interrupt, the following has to be made exactly in the order given:

- 1) Replace the current interrupt vector with a vector pointing to the interrupt handling routine.
- 2) Initialize the peripheral that will request the interrupt.
- 3) Adjust the processor priority level if required.

After the interrupt is no longer being used, the following has to be made to restore the original conditions:

- 1) Disable the peripheral requesting the interrupt.
- 2) Return the default interrupt vector (pointing to the error handling routine).

- 3) Return the processor priority level if modified.

The address of the memory location containing the interrupt vector is computed by adding the corresponding offset to the start address stored in the VBR. The offset is 64H for INT1 level autovector, 68H for INT2...up to 7CH for INT7.

From the user point of view it is very convenient to build interrupt routines into high-level language programs that can be handled or compiled as any other program. The compiler produces relocatable .EXE program files: the operating system considers that an .EXE file can be executed on any memory address. However, the exception vector table contains absolute addresses. The program should therefore include a routine to compute the interrupt routine address dynamically each time the program is executed on a new memory location.

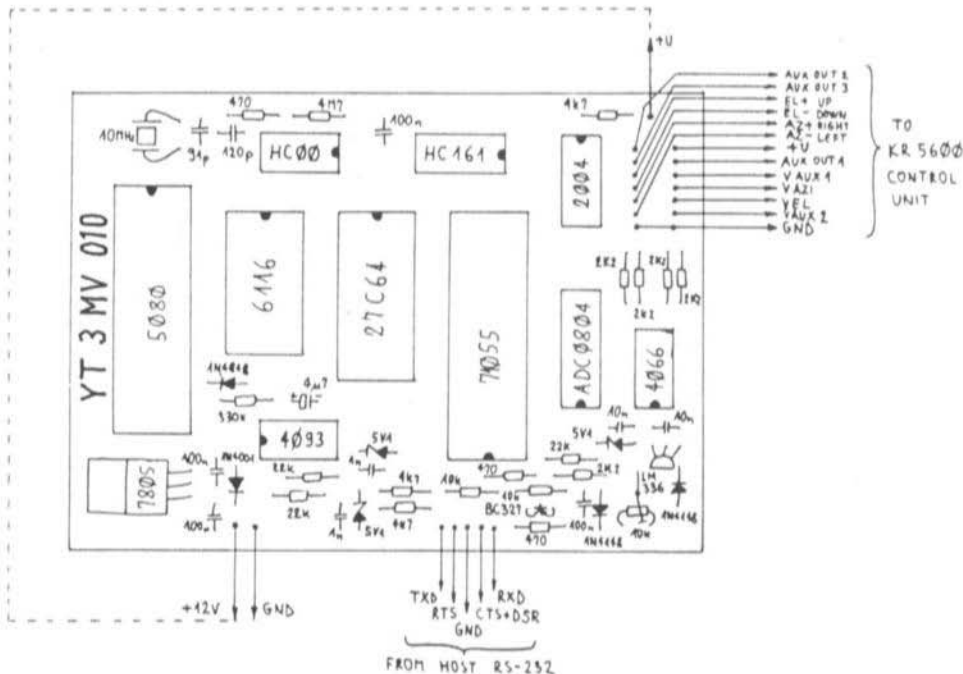


Fig. 3.16.: Interface board for the KR-5600 rotators (YT3MV 010)

In the case of the MC68010 it is convenient to use the Load Effective Address instruction, in particular LEA d (PC), An to find the actual program counter. The address-finding routine is usually located just in front of the interrupt routine so that the unknown start address can be computed easily.

Interrupt routines are usually DSP routines written almost entirely in machine code. However, high-level language expressions are necessary to interface to the rest of the program. Whenever a call to an interrupt routine is made, it is necessary to save the content of the microprocessor internal registers on the stack and restore it before exiting from the routine. Considering the many MC68010 internal register, this operation may be very time consuming.

Since most DSP machine code routines only need a few registers, only the latter are saved and restored before exit to save CPU time. High-level language expressions, however, use all MC68010 registers!

Programs designed for use in an interrupt-driven multitasking environment require some additional features. Since different interrupt routines may belong to different main programs and the interrupt nesting is arbitrary, the content of all microprocessor registers is completely unknown when entering an interrupt routine. If high-level language expressions are used in interrupt routines, the values of registers containing base addresses, usually A4 and A5, have to be restored for correct operation.



3.8. CONCLUSION

As already mentioned in the first, theoretical part of the article, the DSP computer described is only a very successful prototype able to solve many practical problems. We will probably not have to wait long to see much more powerful computers built with new devices designed especially for DSP. We probably still have to invent most applications of DSP in amateur radio too.

It is very difficult to describe a complex electronic circuit in the limited space of a few magazine articles without omitting important details. I would recommend to all users to order a copy of the "Operating System Manual" (about 15 sheets A4) which includes a detailed description of all operating system commands, text editor and high-level language compiler. I preferred not to publish the manual in the magazine since it would be very boring to all readers not immediately interested in this DSP computer.

Those interested in writing DSP software will certainly need more information on the hardware used, especially the MC68010 microprocessor. During the development of this computer I used the following publications from Motorola:

- 1) 16-bit Microprocessors Data Manual, 1983.
- 2) M68000 16/32-bit Microprocessor Programmer's Reference Manual, 1984.

Data on memories and peripheral devices were obtained from several data-books and data-sheets from NEC, Western Digital, Zilog, National Semiconductor, Mostek, RCA, Fairchild and Matsushita. All the above information on the components used includes more than 1000 pages A4.

Both design and construction articles mainly discussed the hardware and the operating system software. As the application software was only briefly mentioned in the foregoing articles, a detailed description will be given in part 4 of this series. Although software changes quickly, it will certainly be useful to mention what can be done with this computer

up to now. A whole bench full of different interface modules for digital transmissions, including FAX and WEFAX, will become superfluous.

This is the justification of the financial expense of this DSP computer and its software. Its greatest advantage will become clear however when experimenting is done or if transmission standards are changed; in these cases, hardware interface modules will become obsolete, the DSP computer only needs a modified program or just a modified program parameter.

Besides the five application programs mentioned in the theoretical article, the actual application programs include:

- * AO-13 400 bps PSK telemetry reception (implemented)
- * Meteosat WEFAX reception (tested)
- * SSTV RX/TX (planned)
- * Audio recorder with variable playback speed (tested)
- * FFT audio spectrum analyzer (planned)
- * AX.25 communication modems up to 2400 bps (tested)
- * Advanced protocols with error correction coding (planned)
- * Ranging for satellite orbit determination (planned)

Many other programs and some hardware (an EPROM programmer module) were developed just as tools to work on the hardware and on the operating system. I decided not to describe them since they are probably not interesting for the majority of readers.

At the end I hope this series of articles will stimulate more amateurs to experiment in the DSP field. Maybe the capabilities of the DSP computer shown are not comparable to what the leading semiconductor manufacturers are advertising on their data-sheets, but do not forget that there is a long way from the data-sheet to a working DSP project. In any case, the described DSP computer was found much more versatile than the originally planned successor to the APT scan-converter and in some cases it performed even better than dedicated DSP computers.



Jürgen Dahms, DC Ø DA

The "microline 3" Transverter System

The Break-through in 10 GHz Experimental Communications

Part 1

1. HISTORICAL REVIEW

The 10 GHz amateur band has always been the most fascinating SHF band for the experimental radio amateur. For a long time now the legendary Gunnplexer has been regarded as **the** means of communication. It doesn't present any constructional problems and enables, in conjunction with an appropriately high-gain parabolic antenna, extraordinarily good radio contacts over great distances – providing that the working frequency of the distant station has been found!

In the seventies, many radio amateurs were dedicated to the construction of narrow-band transverters using semi-conductors. It was proved experimentally that there was an indisputably 30 dB gain to be had over the wideband systems (1). In the meantime, it became clear through various experiments, that the advantage of an almost 30 dB system gain, as opposed to the wideband techniques, was well proven and could not be disputed. Even the process of setting up a contact is very much facilitated owing to the exclusive use of crystal control.

The transverter which was – and still is, especially in Great Britain – that published by G3JVL (2).

At the end of the seventies, beginning of the eighties, one saw a rapid development in narrow-band systems, partly in printed-circuit technology and in the employment of GaAs-FETs. One call sign which will immediately come to the mind of any GHz amateur is DL 1 RQ (ex DL 8 RAH) (3). His transverter was mainly emulated, and operated, in southern Germany and in neighbouring countries such as Austria, Switzerland and Italy.

At the beginning of 1986 came the real breakthrough: using a total of only three modules (described here), a respectable transmit output power of some 200 mW as well as a very good receive sensitivity possessing a noise factor of approximately 2.5 dB was achieved.

Intentionally, there will be no single PCB design presented here, the main characteristic aimed for being exchangeability and flexibility of both send and receive modules. Particular value is laid upon system fidelity and the ability of modules to be exchanged without comprising overall system specifications. Modern techniques

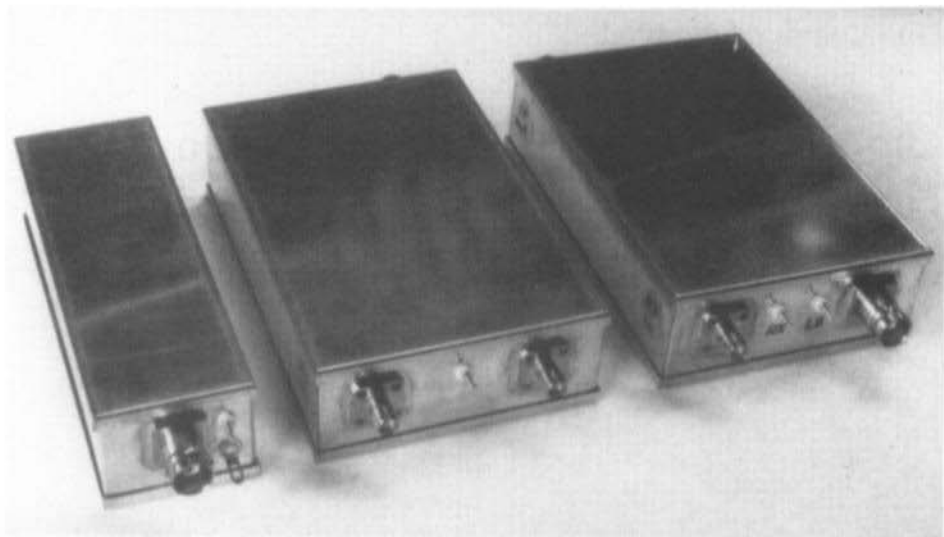


Fig. 1: The three modules comprising the "microline 3" 3 cm transverter

are employed and waveguide constructions completely dispensed with.

This development could only be undertaken by the author with close co-operation from the firm SSB Electronics as they possessed all the equipment necessary for evaluation purposes. With the practical assistance of DJ 4 GC, miniature cavity resonators possessing a good value of Q were constructed for the selective circuits. They enabled an harmonic suppression of better than 40 dB in the transmit portion to be achieved. The employment of commercial test equipment for the development of the project was absolutely indispensable. Calculations were carried out but they were always verified comprehensively by means of the spectrum analyser before commitment to the design was contemplated.

Disappointing experience with the biasing of FET gates by means of a separate supply did entail a bit of experimentation for the choice of low-loss plate capacitors for the source decoupling in order to generate the gate bias automatically. Source biasing has been regarded with some trepidation even by experienced SHF constructors. These experiments were successfully con-

cluded. The employment of SMD techniques, and the (almost) consequent use of striplines, automatically solved the problem.

So far, more than a hundred completed modules have been supplied to amateurs, both at home and abroad, without any real technical problems being reported. Not only was a USA distance record established (400 km) but also the equipment was used for successful 10 GHz EME experiments. The popularity of this 10 GHz transverter line prompted ideas about making it available as a home construction project for the SHF amateur in the form of a three-module kit. This is supplied together with detailed point-by-point construction and alignment instructions. Various methods of testing and test equipment, a prerequisite for a successful alignment, are given in table form together with references. A spectrum analyser, although indispensable for development purposes, is in no way necessary for the completion of this project.

The "microline 3" comprises three modules (fig. 1) having the following designations: -



- XLO-1: 2.5 GHz frequency processing
- XRM-1: 10 GHz receive mixer
- XTM-1: 10 GHz transmit mixer

These modules will be the subject of this multi-part descriptive article.

The author's desire is to stimulate amateur radio experimentation by, as a first step, building his own 10 GHz station. The ever increasing requests for individual printed circuit boards and special-to-type components can, from now on, be satisfied. These serve to reflect the great interest displayed in the 10 GHz amateur band.

The driver transceiver can be a normal commercial 2-metre unit having a transmit output power of between 20 mW and 3 W such as, for example, the FT 290 or IC 202. Both these transceivers are eminently suitable for use with the "microline 3" equipment for 10 GHz portable operation.

2. LOCAL OSCILLATOR XLO-1

The local oscillator module uses a double-sided glass-epoxy printed circuit board of dimensions 35 x 108 mm. It is pre-drilled and galvanically tinned and fits into a prepared tin-plate container of dimensions 37 x 111 x 30 mm. The module delivers a crystal-controlled 2556 MHz signal to drive the 10 GHz receive mixer XRM-1 with an output power of at least 5 mW.

2.1. Circuit Description

The low-noise output from a 106.5 MHz crystal oscillator is multiplied by a factor of 24 to bring the unit output to the required frequency of 2556 MHz (see fig. 2).

$$Q = 106.5 \text{ MHz} \text{ --- } \times 3 \text{ --- } 319.5 \text{ MHz} \text{ --- } \times 2 \text{ --- } 639 \text{ MHz} \text{ --- } \times 2 \text{ --- } 1278 \text{ MHz} \text{ --- } \times 2 \text{ --- } 2556 \text{ MHz}$$

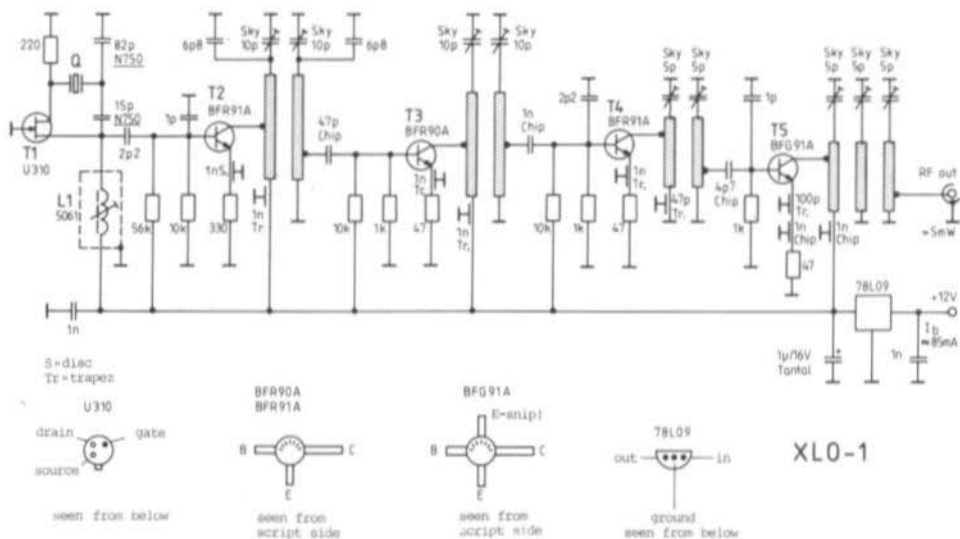


Fig. 2: The oscillator/multiplier module XLO-1 delivers 5 mW at 2556 MHz



The individual multiplier stages are coupled through band-pass filters, a loosely coupled 3-stage filter being used at the output of the unit. In this manner, a clean output spectrum is assured with a spurious level suppression of greater than 40 dB. An on-board voltage regulator (9 V) makes the unit secure from the effects of external supply voltage fluctuations. An extremely stable (TK = 10 ppm) crystal, which is also temperature-compensated, very adequately assures a sufficiently frequency-stable operation.

Although the construction and alignment of this unit presents no serious problems for the experienced constructor, both facets are taken care of by detailed step-by-step instructions. This should compel the constructor from the very start to adopt a careful approach thus leading to an exact and problem-free construction of both this and, subsequently, the XRM-1 and the XTM-1 modules.

2.2. Installing the XLO-1 Board in the Tin-Plate Housing

1. Set the side walls of the tin-plate box in the top cover such that the two punched holes point to the bottom plate.
2. Spot solder the side walls temporarily together at their upper corner edges.
3. Position the M3 x 12 mm cheese-head screws in the corners of the housing.
4. Fit the board into the housing frame with the ground-plane side uppermost and resting on the four M3 screws, if necessary filing the edges to obtain an exact fit.
5. Solder the board all the way around its perimeter to the housing walls.
6. Take the housing frame complete with board from the bottom plate and complete the soldering of the side-wall corners both above and below the board.
7. Trim the fixing pins on the print BNC socket and

file the residue off. Trim the BNC socket connector spigot and finish off with a file. Pressing the socket to the tin wall, solder the centre spigot to the 3-stage filter output track.

8. Solder the BNC mounting flange, all the way around its perimeter, directly to the side wall.
9. Fit the PTFE through connector in the appropriate hole and solder the central spigot to the PCB track.

2.3. XLO-1 Component List

- 1 PCB XLO-1 (drilled and tinned)
 - 1 Tin-plate enclosure (pre-fabricated) (37 x 111 x 30)
 - 1 Crystal, HC 18/U series resonance
f = 106.500 MHz
TK \pm 10 ppm (-20 to +70°C)
 - 1 Neosid inductor 5061 (blue/brown): L1
 - 1 Teflon feed-thru'
 - 1 BNC print socket
 - 1 5 cm CuL 0.5 dia
 - 1 Voltage regulator 78L09
 - 1 U 310: T1
 - 1 BFG 91 A: T5
 - 1 BFR 90 A: T3
 - 2 BFR 91A: T2, T4
 - 4 Miniature plastic foil trimmer type Sky, 10 p, black
 - 5 Miniature plastic foil trimmer type Sky, 5 p, green
 - 1 disc capacitor 1 n
 - 4 Trapez. cap. 1 n
 - 1 Trapez. cap. 100 p
 - 1 Trapez. cap. 47 p
 - 3 Chip cap. 1 n
 - 1 Chip cap. 4 p 7
 - 1 Chip cap. 47 p
 - 1 piece of thin Cu-foil 20 x 20 mm approx.
 - 2 Capacitors 1 nF
 - 1 Tant. elco 1 μ F/35 V or 1 μ F/16 V
 - 1 Cap. 82 p, TK: N750 (lilac)
 - 1 Cap. 15 p, TK: N750 (lilac)
 - 2 Cap. 6 p 8
 - 2 Cap. 2 p 2
 - 2 Cap. 1 p
- Resistors
- 1 56 k

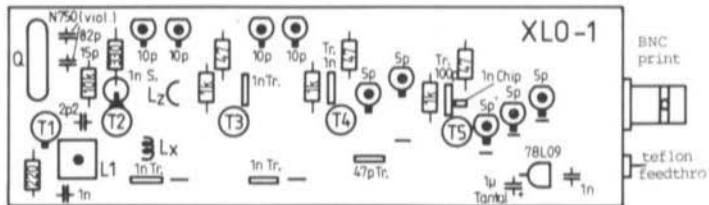


Fig. 3:
XLO-1 module component layout plan (ground plane side)
 $L_x = 3$ turns CuL 0.5 mm dia. wound over 2 mm former
teflon Feedthro'
 $L_z = 1/2$ turn CuL 0.5 mm dia. wound over 3 mm former

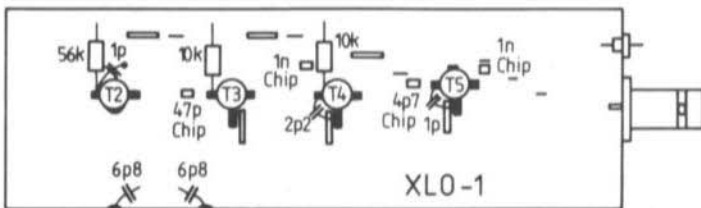


Fig. 4:
XLO-1 module component layout plan (track side)

- 3 10 k
- 3 1 k
- 1 330 Ω
- 1 220 Ω
- 3 47 Ω

2.4. Equipping PCB XLO-1

Figures 3 and 4 show the component layout of this board from both sides.

1. Through-connect to ground the stripline band-pass-filter circuit, complete with connection hole for the 1 nF chip capacitor, to the first stage of the 3-pole filter.
2. File out the drilling for T2 with a mouse-tail file so that the emitter leads can be passed through.
3. Solder the disc capacitor for T2 emitter to the PCB.
4. Solder all the trapezoidal capacitors (note, 3 different values).
5. Snip the centre connector from the Neosid inductor and also two of the screen-can fixing lugs. Put the inductor into the holes provided. The

screening can is soldered by the two opposite lugs to the ground side of the PCB.

6. Solder-in the crystal and then quickly spot solder the narrow side of its housing to the ground plane of the PCB.
7. Solder-in T1 (U 310), the transistor housing must lie flush with the PCB's surface. Quickly spot solder the housing tab to the PCB ground plane.
8. Solder in all the transistors and the voltage regulator in accordance with the lay-out plan. The transistor connector leads must be shortened beforehand as required. The emitter lead of T2 (BFR 91 A) must be bent downwards through 90° and soldered to the disc capacitors. An emitter lead of T5 (BFG 91 A) is snipped off. Ensure that the printing on the transistors is legible from the track side of the board!
9. Solder in all the six capacitors which are installed from the ground-plane side as in fig. 3.
10. Fabricate the air-coils for the 319.5 MHz band-pass filter according to the instructions given in the title to fig. 3 and solder in from the ground-plane side.

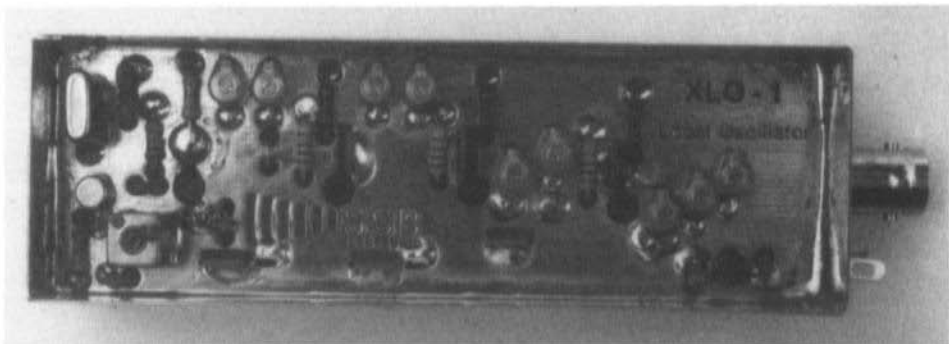


Fig. 5: Plan view of the XLO-1 module

11.

Install all the foil trimmers pressing the plastic bodies onto the board and solder the previously bent connector leads to ground via the shortest possible route. Snip off any protruding connector lead ends on the PCB track side. Should the foil trimmers be too stiff to turn, they can be freed by means of a light hammer blow to a screwdriver applied to the rotor slot. This must not be overdone as the spring washer must have sufficient force to ensure a good sliding earth contact.

12.

Solder in all the eight resistors which go on the ground-plane side of the board (see fig. 3).

13.

Solder in the remaining resistors, including the chip resistors, also the capacitors and chip capacitors, all of which go on the track side of the board in accordance with fig. 4. The base capacitors for T2, T4 and T5 are soldered upright between base and emitter and as near as possible to the transistor. It could be that the visible portion of T2's emitter lead is not long enough to solder. If this is the case, drill out the board with an 0.8 mm drill in order to make the ground contact.

14.

In order that the emitter of T5 (BFG 91 A) is better de-coupled, a 1 nF chip capacitor is placed, on the PCB ground-plane side, in parallel with the 100 pF trapezoidal capacitor.

15.

The board is then inspected for faulty soldered joints and other wiring defects. The photos of

figs 5 and 6 show a completed example of the module XLO-1.

2.5. XLO-1 Alignment

1.

Turn all trimmers fully out (min. capacity) and all coil slugs so that they are on the extreme edge of the coil former.

2.

Close the module and connect the 12 V power supply via the multimeter (range 100 mA). A current of some 16 mA should be flowing in the ground lead.

3.

Slowly turn the oscillator coil-core in until the current rises from 16 mA to 24 mA. The crystal is then oscillating at its nominal frequency.

4.

Turn the collector trimmer of T2 in by about 1/3rd and the base trimmer of T3 in by 2/3rds. Then by a process of iteration, tune them until the current rises to a maximum of around 44 mA. The output frequency of 319.5 MHz should then be verified with an absorption wavemeter (1)(2).

5.

Turn the collector trimmer of T3 and the base trimmer of T4 in by about 1/3rd and tune for a maximum current rise at around 76 mA. By tuning the trimmers, only **one** current peak should be obtained in order that the unit is tuned to the output frequency (only) of 639 MHz.

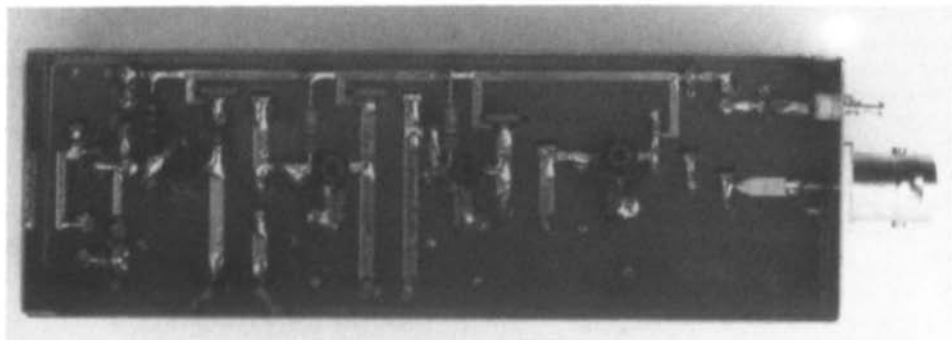


Fig. 6: The under side of the XLO-1 module

Nevertheless, this should also be verified with a frequency counter (see 4 above).

6.

Turn the collector trimmer of T4 and the base trimmer of T5 in by about 1/3rd and tune by iterating between these two controls until the current rises to a maximum at about 100 mA.

The frequency of 1278 MHz is clearly available now (check as before) but the output impedance is not yet matched to the output transistor T5.

7.

The trimming tools should fit the tuning slots exactly and be entirely of plastic with **no metal tips**. The collector trimmer of T5 should be tuned carefully so that the module input current decreases by 4 mA (this corresponds to about a 1/5th of a turn or less).

8.

Connect a power meter (bolometer (3)(4), or Wattmeter (5)) which has been previously set to the 10 mW range, to the frequency multiplier output.

9.

The first two trimmers of the 3-pole filter are turned slowly (about 0.5 mm). The power-meter reading should immediately start rising from nearly zero deflection to about 5 mW when the middle trimmer is turned.

10.

The output frequency of 2556 MHz should be verified with a calibrated frequency probe according to (6).

11.

Fine-tune all the multiplier trimmers, by iteration between them, until a maximum power output of 10 mW is attained.

This tuning process should result in a reduction of the multiplier current to a total of some 85 mA. By carefully turning out the oscillator coil-core, the total multiplier current should return to its original value of 16 mA.

Finally, the oscillator tuning stability should be checked by disconnecting and reconnecting the multiplier supply voltage a few times. Each time it is reconnected, the power should return to the same finalized tuning value.

If care in both soldering and alignment has been exercised, more than 10 mW at the reduced value of supply current should be obtained. Naturally, the exact output power will depend upon the manufacturing tolerances of the semi-conductors which have been employed.

Only 5 mW output power is sufficient to drive the multiplier of the receive-mixer XRM-1 so that the multiplier has, in fact, more than 3 dB power in reserve.

2.6. Technical Details of the XLO-1 Module

Output frequency	2556 MHz
Output power	5 mW (min.)
Harmonic output	< 40 dBc (min.)
Frequency stability (+ 5 to + 30° C)	10 ppm (min.)



Supply voltage (onboard stab.) 12 - 15 V
 Supply current (typ.) 80 mA
 Output connector BNC
 Dimensions (w/o skt.) 74 x 37 x 111 mm
 Weight 100 g

(2) G 3 JVL:
 10 GHz Narrow-band Transverter
 Microwaves, Jan. 1979
 Suckling, Charles, G 3 WDG:
 Further Information on the G 3 JVL
 10 GHz Transverter
 Radio Communication, April 1980

2.7. Literature to the Historical Review

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 The 10 GHz Amateur Bands – Consideration
 of Present and Future Technologies.
 Part 1 and 2
 VHF COMMUNICATIONS Vol. 10.
 Ed. 4/1978, p. 244 - 251
 VHF COMMUNICATIONS Vol. 11.
 Ed. 1/1979, p. 34 - 42

(3) Vogl, P., DL 8 RAH:
 10-GHz-SSB-Transverter in Modulbauweise
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 Neuentwicklung 10-GHz-SSB-Transverter
 DUBUS, Heft 4/1986

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Interesting for all active and technically minded Radio Amateurs

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Armin Meier, DC 7 MA

Further Improvements to the DJ 4 LB 002a ATV-TX Audio Section

The construction of the sound-PLL following the design by DF 6 WU (VHF COMMS. 1/88) was, as far as I was concerned, fraught with difficulties.

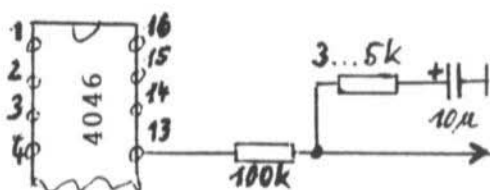
1. The oscillator was able to oscillate on all the harmonic overtones of 9 MHz except the 3rd., i.e. 26.720 MHz.

Remedy: A 47 pF capacitor connected between the base and emitter of T1. Perhaps it was the crystal that I used, as these CB crystals seem to have a will of their own!

2. The level presented to the following buffer stage (T2) was very low, making it very difficult to set the working point of the 7400 IC.

Remedy: By using a 74LS00, the driving power needed from the buffer is very much reduced thereby increasing the output voltage of the buffer and making the working point of the IC much easier to set. This IC functions without any difficulties despite the warning about using LS types. Various LS types from differing manufacturers were tried, all without difficulties. Also, the 33.4 MHz signal path (T3) through the IC was much easier to adjust.

3. Since the gates in the LS version functioned without any trouble, the other 74-series ICs were replaced with LS types. Even the divider chain exhibited no problems! Nevertheless, various examples from differing manufacturers were tried.



AFC voltage to VCO

Fig. 1:
An improved
loop-filter

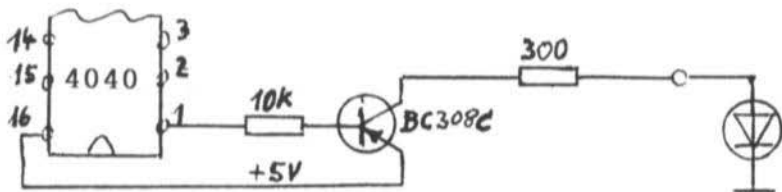


Fig. 2:
A more
informative
"lock" indicator

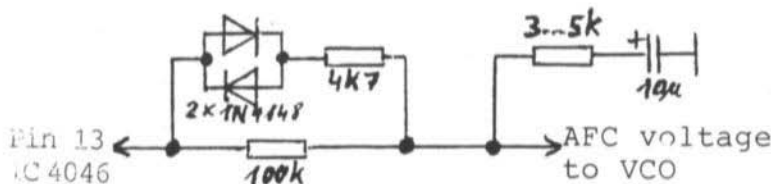


Fig. 3:
Shortening the
lock-in time by
providing a low-
resistance path
for high AFC
voltages

The positive result was a smaller current consumption for the unit and, as a consequence, less heat developed by the voltage regulator.

4. The PLL did not lock in cleanly. Listening to the 33.4 MHz signal with a receiver in mode SSB didn't sound too good. The VCO was hunting around the nominal frequency, sometimes quickly, sometimes very slowly before finally locking-in. An externally induced impulse from, for example, switching on the soldering iron was sufficient to cause the PLL to break lock and allow the carrier to start hunting again. By suitably tuning the SSB receiver, a noise reminiscent of a two-stroke motor could be obtained!

Remedy: A 3 to 5 k Ω resistor is placed in series with the loop capacitor (10 μ F) as shown in fig.1.

5. The LED does not really mean a great deal as there doesn't appear to be much difference in the indication between a hunting condition and a solid lock of the PLL. The LED might as well not be there at all.

Remedy: The LED operating logic is changed around; pin 1 of the IC 4046 controls a PNP transistor via a 10 k Ω resistor. The emitter is connected to + 5 V and the collector via a 300 Ω

(approx) resistor and LED to earth. **See fig. 2.**

- | | |
|----------------------|--|
| LED on | = PLL out of lock |
| LED flickers | = PLL is not properly locked-in but is hunting near the selected frequency |
| LED intensity varies | = Normal during modulation peaks but could signify over-deviation. Also PLL out of lock. |
| LED out | = PLL properly locked. |

6. Lock-in time is too long (1 to 2 s).

Remedy: A network comprising two 1 N 4148 diodes, in anti-parallel, and a series 4.7 k Ω resistor is connected across the existing 100 k Ω loop-filter resistor (**see fig. 3**).

Should the AFC voltage exceed ± 0.6 V, the current flows via the diode network thus limiting the AFC voltage to that value. A fine control is then effected via the 100 k Ω resistor. The lock-in time is then reduced to a few milli-seconds and without affecting the deviation.

7. The AFC line should be screened.

Remedy: Use screened or co-ax cable for this line.



Armin Meier, DC 7 MA

ATV-Sound PLL for the DJ 4 LB 002a Board

Owing to the difficulties experienced with the above unit, as conceived by DF 6 WU, a completely new circuit was developed which may be duplicated immediately and without any adjustment procedures to bother with. The DF 6 WU circuit may have functioned well on the prototype but has been found critical when duplicated.

1. CIRCUIT DETAILS

1.1. Crystal Oscillator

The crystal oscillator is driven with a somewhat higher output voltage and supplied from the 5 V rail, see fig. 1.

1.2. Level Adjustments

The circuit for the HF-level matching, as well as that of the VCO, has been borrowed from a

broadcast transmitter which also works with PLL circuitry. The level from this stage is already high enough to drive a frequency counter and no adjustment is therefore necessary, see fig. 2. The VCO must not be worked flat out, reducing the output functions just as well.

1.3. Divider Chains

The following divider chains were taken directly from DF 6 WU's circuit, except that in each chain a divide-by-ten stage was added. This means that the PLL now functions with a tenth of the VCO frequency alterations. The following drive to the 4046 IC is identical.

1.4. Loop-Filter

The output of the PLL IC 4046, pin 13 was taken from the circuit suggestions given in (1), (2) and (3). The loop-filter comprises an R-R-C combination as shown in figure 3.

The LED drive logic was changed to improve its intelligibility as an indicator.

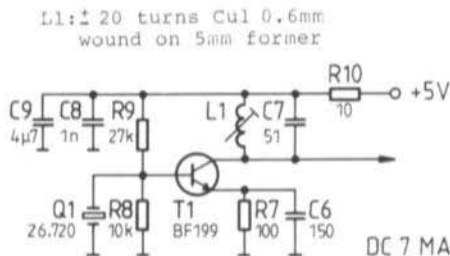


Fig. 1: The improved crystal oscillator

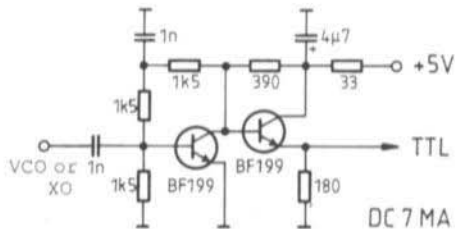
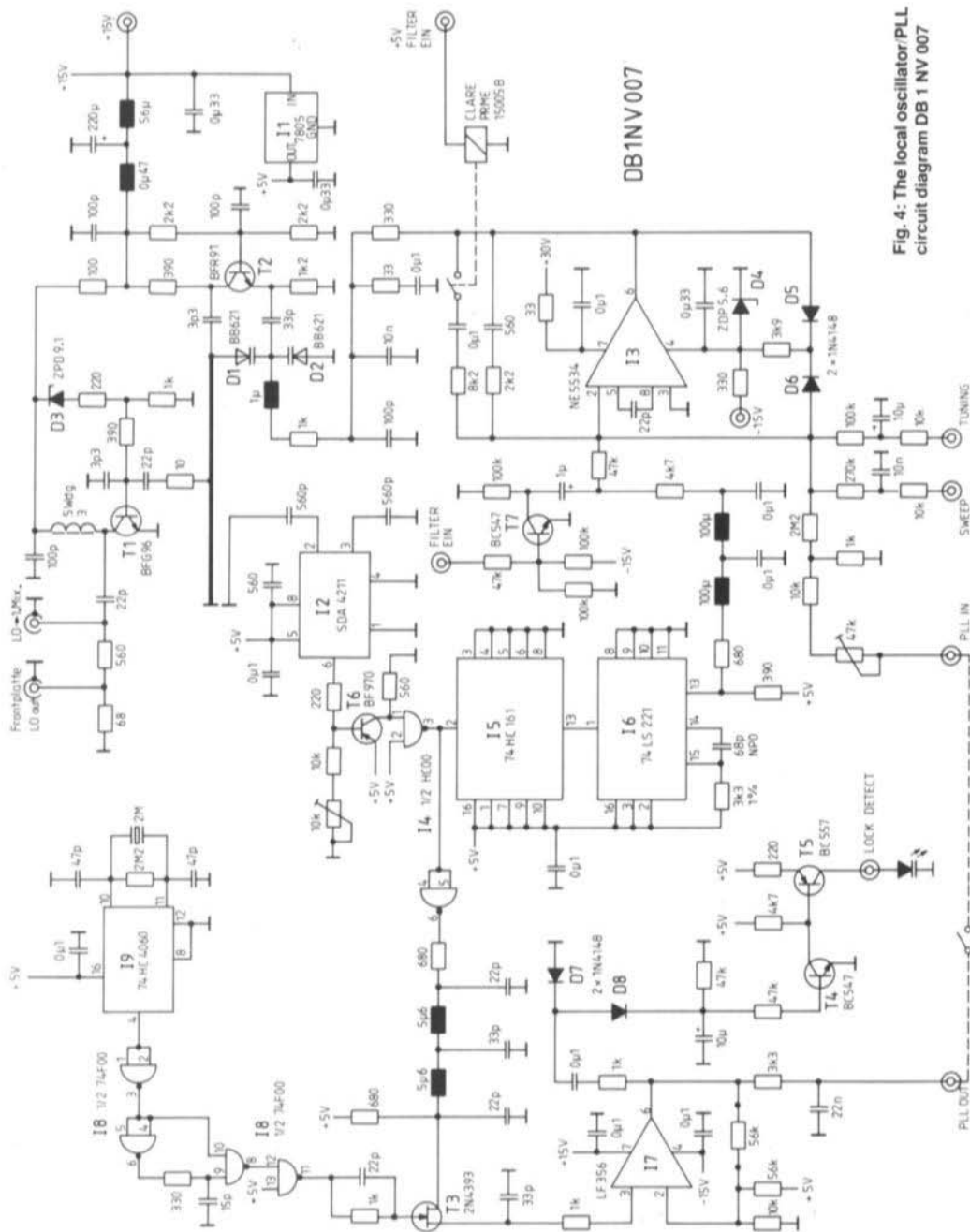


Fig. 2: Circuit to convert to TTL-level





Dr. Eng. Jochen Jirmann, DB 1 NV

A Spectrum Analyser for the Radio Amateur Part 3: Construction and PCBs

In VHF Communications 1987 editions 3 and 4, a concept, together with the necessary circuits, was presented for a spectrum-analyser intended for amateur radio use and which covered the ranges 0 - 500 MHz and 1000 - 1500 MHz. In the meantime, this concept has been further developed into an operational piece of test equipment which is able to be replicated without fear of encountering teething troubles. The following design objectives were achieved with the instrument: -

- * The number of constituent units was reduced to four.
- * Critical inter-unit cable connections have been avoided by careful arrangement of circuits within each module. For example, the VCO and PLL/FLL unit is located together thus avoiding the noise-sensitive VCO control line and HF cabling.
- * The equipment's specification was gradually improved so that a continuously adjustable bandwidth crystal filter as well as a switchable video filter is now available. The noise sideband characteristics of the VCO were also improved.
- * A smaller circuit complexity also simplifies the construction, for example, an integrated circuit now replaces the discrete-component logarithmic IF-amplifier. This IC was designed for use in high-quality stereo receivers. The critical sampling PLL now works at lower frequencies.

The spectrum analyser now consists of the following four units: -

1. The HF/IF unit containing the input mixer, the first (470 MHz) and second (10,7 MHz) IF, the wideband IF filter and the logarithmic IF amplifier.
2. The local-oscillator module which comprises the VCO from 470 to 1000 MHz with frequency- and phase-locked loops.
3. The variable bandwidth crystal filter.
4. The sequence control together with video filter.

The individual units will now be described but only as far as they differ from those described in the previous articles.

But before the unit description commences, here is an important advice to all potential builders of this project:

The instrument represents a very complex system which requires a great deal of experience in HF circuitry as well as access to the following test equipment for alignment: -

- digital multimeter
- frequency counter to at least 1 GHz
- oscilloscope with at least a 20 MHz bandwidth
- sweep generator to 500 MHz
- narrow-band sweeper for 10.7 MHz (can be self-constructed)
- function generator
- spectrum generator
- signal generator (or a sweep generator) with

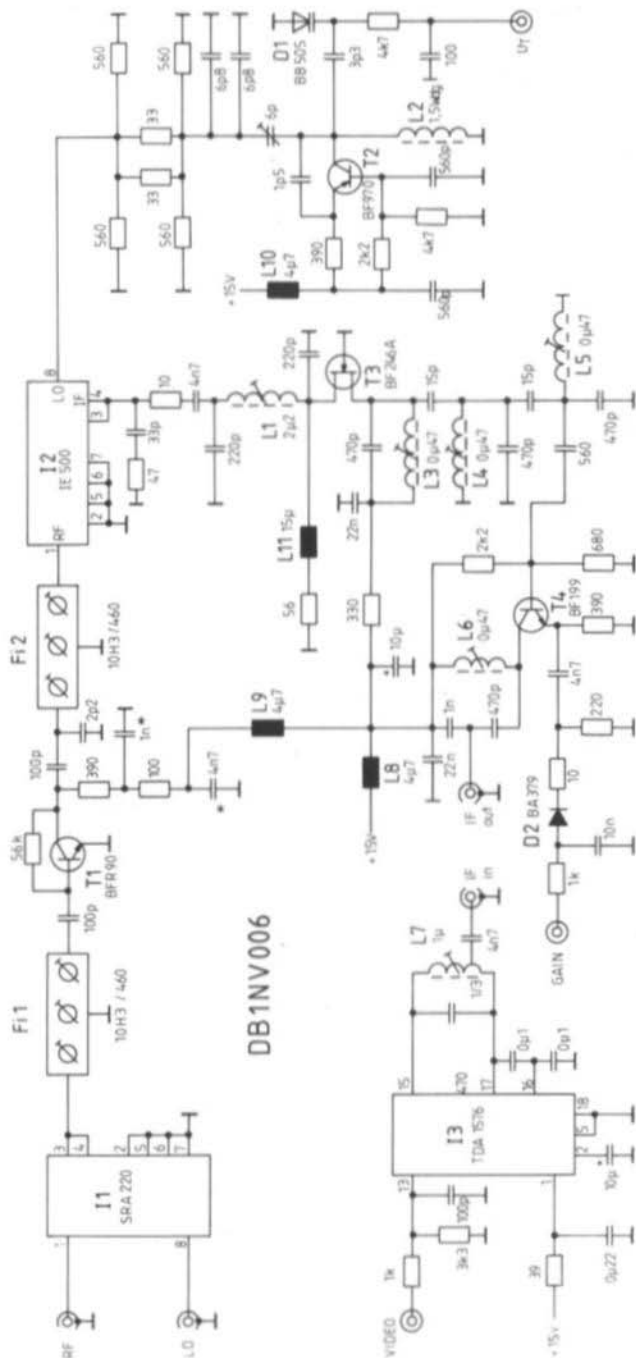


Fig. 1: The HF/IF module DB 1 NV 006. The components appended with an asterisk are leadless plate capacitors on the PCB groundplane

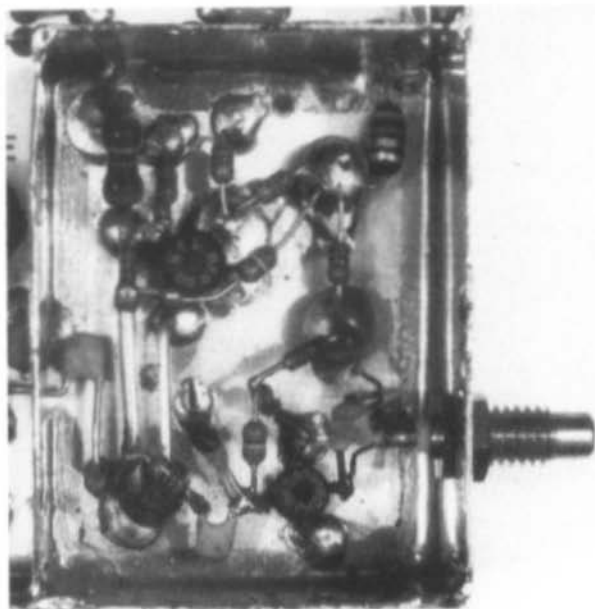


Fig. 8: The VCO's "rats-nest" wiring

If the HF output power greatly departs from that given above, it can be corrected by changing the emitter resistor of T2 in the range of $560\ \Omega$ to $2.2\ \text{k}\Omega$. The tuning range can be corrected by adjusting the length of the tuned line. If the frequency lies too low, a small loop of about 5 mm length, both ends being soldered to ground and located at the cold end of the tuned line, can be used for fine corrections. The loop is simply bent to a position such that the counter inductance, induced into the tuned line, results in a higher frequency.

After the VCO is working properly, the functioning of the frequency divider, SDA 4211, and of the voltage level changers can be controlled with T6 and I4. Pin 3 of I4 serves as a test point to check the VCO frequency divided by 64. If necessary, the working point of the level changer can be corrected with the $10\ \text{k}\Omega$ preset pot'meter. The I5 (divide by 4) and the following monostable I6 is checked by monitoring the pulses at pin 13 of I6. These pulses have an approximate width of 200 ns and a PRF of 2 to 4 MHz. The important

point is, that at the highest VCO frequency there remains a 50 ns period between pulses for the monostable in order to inhibit mis-triggering. If required, the monostable's period may be matched by variation of the components ($3.3\ \text{k}\Omega/68\ \text{pF}$) connected to pin 14 and 15. After these tests, the frequency control loop may be closed. Now, the remaining supply voltages, $-15\ \text{V}$ and $+30\ \text{V}$, are be connected to the module.

A variable DC voltage of -4 to -10 volts, connected to the tuning input, should tune the VCO linearly. The exact limits of tuning depend upon component tolerances, especially those of the monostable.

The function of the PLL can be verified by observing the sampling pulse at pin 11 of I8 with an oscilloscope (this really requires an oscilloscope with a 200 MHz bandwidth) and by monitoring the mixing frequency at pin 6 of I7.

When the PLL loop is closed with the wire bridge from "PLL out" to "PLL in" and the time constant of the control loop amplifier has been switched,



by application of the switching potential of 5 V, the PLL will lock at the 2 MHz step when the VCO is tuned slowly. This is manifest in the fact that I7 now delivers a DC voltage which varies as the VCO is slowly tuned (or by de-tuning the VCO by touching it lightly with a finger).

Tuning further will lock the VCO on to the next frequency step. The 47 k Ω potentiometer in the PLL circuit is then set to the most stable quiescent condition. Normally, this occurs in the middle of the slider's travel. The most critical item is the lock condition at the lower end of the tuning range as the loop tuning control signals have a faster rise time and therefore the greater tendency for the pulses to exhibit over- and under shooting.

The lock detect circuit is verified by simply connecting an LED: it should extinguish when the PLL is in the lock condition. If the reverse is to be preferred, i.e. LED illuminated when correctly locked, transistor T5 is simply replaced with an NPN transistor, e.g. BC 547 etc, whereby the emitter is connected to the LED. The PCB has been designed to accommodate both variants.

2.2. Component List for DB 1 NV 007

Semi conductors:

I1:	LM 7805
I2:	SDA 4211 (Siemens)
I3:	NE 5534 (low-noise op.amp., Valvo)
I4:	74HC00
I5:	74HC161
I6:	74LS221, see text
I7:	LF 356
I8:	74F00, 74AS00

I9:	CD 4060, 74HC4060
T1:	BFG 96, BFR 96
T2:	BFR 91
T3:	2N 4393
T4, T7:	BC 547
T5:	BC 557
T6:	BF 970
D1, D2:	BB 621, second choice BB 505
D3:	ZPD 9,1
D4:	ZPD 5,6
D5, D8:	1N4148

Resistors:

- 1 preset 10 k Ω , grid 5 x 10 mm, horiz.
- 1 preset 47 k Ω , grid 5 x 10 mm, horiz.
- 1 resistor 3.3 k Ω , 1 % metal (at pin 15 of LS 221)
- other resistors: series 0204 or 0207

Capacitors:

- Ceramic capacitors under 1 nF, grid 2.5 mm, 4 leadless plate, approx. 100 pF, for decoupling in VCO; bigger capacitors: foil, grid 5 mm or elkos, upright, grid 2.5 mm

Inductors:

- 1 mini RFC 0.47 μ H
- 1 mini RFC 1 μ H
- 2 mini RFCs 5.6 μ H
- 1 mini RFC 56 μ H
- 2 mini RFCs 100 μ H

Miscellaneous

- 1 PCB DB 1 NV 007
- 1 tin-plate housing 148 x 72 x 30 mm
- 1 crystal 2 MHz, HC 18/U
- 11 feed-thro' capacitors 2.2 nF
- 1 Reed relay: 5 V, single contact, e.g. Clare PRME 15005 B
- 2 mini coax sockets, e.g. Subcllic, SMC

To be continued



Otherwise, the equipping of the unit DB 1 NV 006 should be carried out in accordance with the component layout plan of **fig. 2**. The completed board can be tested and aligned before installation in its tin-plate housing. This makes eventual fault-finding and component replacement so much easier.

The board should be soldered into the housing with an uninterrupted run of solder around the edge of the board. The upper (ground plane) side should be fitted with a long solder tag suitably bent at its end, and soldered to the side wall. This facilitates the running of the solder around the joint by holding the board in position. In the same operation, i.e. when the housing is hot, the feed-through capacitors (2.2 nF) for the DC connections, and the SMC sockets for the HF connections, can also be soldered into the housing. The video output and the 10.7 MHz IF connections can use simple, press-in PTFE feed-through insulators in order to save on SMC connectors – if desired.

Two details concerning the housing are of great importance for the elimination of spurious signals: the through-contacting of the housing top cover as well as the provision of damping material in the housing. As these measures are important in a general sense for HF construction work, they will be dealt with in more detail.

If the HF/IF unit is used in a completed spectrum analyser without its cover, a weak spurious signal at LO₂ (455 kHz) would normally appear on the trace. Upon replacing the cover, a multitude of spurs appear. They are the result of mixing of the oscillator harmonics in the mixer itself. This occurs because the mixer is not matched at the harmonic frequencies and the resulting energy is reflected out on to the walls of the housing which acts like a waveguide. In this manner, the signals from the 1st mixer circumvent the filter and get into the 2nd mixer and the 10.7 MHz IF chain.

There are two ways of avoiding this inadvertent waveguide propagation effect. Either the cut-off frequency of the "waveguide" is raised by using metal baffles into an uncritical range, or the waveguide can be dampened with attenuating material. To dampen the track side of the PCB is not suitable as the wanted signal on the short

strip lines as well as the oscillator circuit would also be attenuated. The remedy is to through-contact the track side of the board through to the housing floor by means of brass screws. The position of these has been experimentally determined and is indicated in the component layout plan.

The same measure carried out on the component side is not, however, successful as the necessary 20 mm long screws would possess quite a large inductance. The cover is therefore fitted with 5 mm thick MOS foam plastic which acts as an absorber material. It should be observed that this foam plastic has widely differing resistive properties according to the amount of carbon used in it. For this purpose, a low resistance, high carbon content material should be employed.

After this excursion into housing techniques comes the alignment of the unit.

1.2. DB 1 NV 006 Alignment

A sweep generator with an output impedance of 50 Ω will be required first of all. A signal of -20 dBm is fed into pin 3 and 4 of I1 and a 50 Ω detector diode is connected between pin 1 and ground of I2. Filters F1 and F2 are adjusted to a mid frequency of between 460 and 470 MHz. The passband curve should be as flat as possible with a bandwidth of some 5 MHz. If this is not attained, check first of all the matching of the detector. A gain of 5 to 10 dB should normally be expected.

The sweep generator is then taken to I2 pin 3 and 4 at a power of -30 dBm. The diode detector is connected to the 10.7 MHz output and the supply voltage for the amplifier is connected to +15 V. Inductors L1 and L3 to L6 are adjusted for a maximum at 10.7 MHz and the characteristic should look clean and rounded – no flat top! Inductor L1 does not have much effect when tuned, but this is normal.

Now, the 2nd L0 can be aligned. Using a voltage $U_T = 6$ V, for tuning purposes, the 6 pF trimmer is tuned for 455 MHz. The frequency may be determined by means of a short "antenna" coupled from the oscillator to the frequency counter.

Finally, the sweep generator is taken to the IF input socket of the TDA 1576. An oscilloscope is



connected to the video output (without the diode detector) and L7 is tuned for a maximum.

By altering the sweep generator's output power in decade steps between -90 dBm and 0 dBm, the correct functioning of the logarithmic amplifier can be checked. Each step should result in a corresponding alteration in the video output to a sensible degree.

Fig. 3 is a photograph of a completed DB 1 NV 006 unit.

1.3. DB 1 NV 006 Component List

Semiconductors:

- I1: Ring mixer SRA 220 (Mini-Circuits)
- I2: Ring mixer IE 500 (Mini-Circuits)
- I3: TDA 1576 (Valvo)
- T1: BFR 90 (Valvo, Siemens)
- T2: BF 970, BF 979 (Valvo, Siemens)
- T3: BF 246a (Texas, Valvo)
- T4: BF 199 (Valvo, Siemens, SGS)
- D1: BB 105, BB 505
- D2: BA 379 or successor BA 389

Inductors:

- F1, F2: Helical filter 10H3/460 (TeleQuarz)
- L1: 2.2 μ H filter kit 7 x 7 mm or Neosid ready-made coil
- L2: Neosid-UHF ready-made coil 0.021 μ H (1 turn removed)
- L3 - L6: 0.47 μ H 7 x 7 mm filter kit or ready-made coil
- L7: 1 μ H, tapped at 1/3, filter kit 7 x 7 mm
- L8 - L10: Miniature RFC 4.7 μ H Siemens MCC
- L11: Miniature RFC 15 μ H Siemens MCC

Resistors:

1/8 W series 0204 or 0207, the 3 dB 2nd LO pad being constructed of series 0204 resistors

Capacitors:

1 PTFE trimmer 6 pF, 2-legged, 5 mm grid
 Small values: ceramic, grid 2.5 mm
 Large values: electrolytics - upright, grid 2.5 mm
 The 10.7 MHz tuned circuit capacitors (470 pF) must be of good quality, either ceramic type 1 or (as in fig. 3) high-quality foil types such as WIMA FKC.

Miscellaneous:

- 1 PCB DB 1 NV 006
- 1 Tin-plate box 54 x 148 x 30 mm

- 4 Miniature coaxial sockets, e.g. Subclac SMC
- 3 Feed-through capacitors 2.2 nF
- 1 Feed-through PTFE insulators for video signal

2. THE LOCAL-OSCILLATOR/PLL UNIT DB 1 NV 007

As already mentioned, the VCO/PLL circuit has been totally changed with respect to the earlier version. It can be seen from the circuit of **fig. 4** that the only part remaining is the actual VCO with T1 and T2. The frequency control loop, which by normal sweeping ensures a linear operation, was considerably simplified.

Referring to fig. 4, it can be seen that the VCO signal is divided by a factor of 64 with I2 (either an SDA 4211 or an SDA 4212). Following a level change with T6 and I4, a further division, this time by 4, is carried out in a CMOS divider. This gives an output frequency of between 2 and 4 MHz when the VCO is being tuned between 500 and 1000 MHz. A monostable type 74LS221 is used as a frequency-voltage converter. It has been determined that the pulse jitter of LS types is smaller than that of the 74HC equivalents. In order that a sufficient sweep output voltage is attained, pin 13 of I6 is given a pull-up resistor.

The frequency-voltage converter, together with a following low-pass filter, produces a VCO frequency-proportional output voltage which is compared to the control IC I3 together with the weighted sum from the tuning voltage, the sweep saw-tooth voltage and PLL control voltage. In order that the required tuning voltage of 0 to 25 volts is obtained for the varicap diodes, I3 is given an asymmetrical supply voltage of +30 V and -5.6 V (produced by D4).

When the 2nd LO is swept, the loop bandwidth is reduced, which reduces the loop noise. This is accomplished by switching transistor T7 and the reed-relay acting in the feedback of I3.

Finally, diodes D6 and D5 form an amplitude-dependent feedback circuit which prevents the output of I3 from being over-driven negatively.

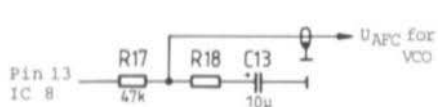


Fig. 3:
The loop-filter

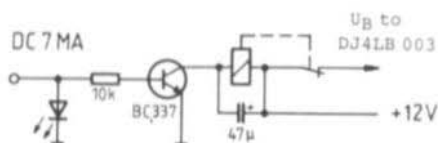


Fig. 4:
Blocking the trans-
mitter in the event of a
PLL mal-function

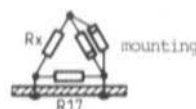
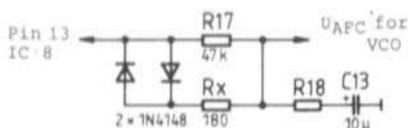


Fig. 5:
Three additional com-
ponents shorten the
lock-in time

- LED on = PLL out of lock. One of the two frequencies (XO or VCO) is not working or the VCO is working outside the capture range of the PLL.
- LED flickers = VCO is on the limit of the capture range. The U_{AFC}

for 33.4 MHz is approx. 2.5 V.

LED intensity varies = VCO level a little low. Only peaks of modulation cause this effect. Intensity variations at all levels of modulation indicate an excessive deviation.

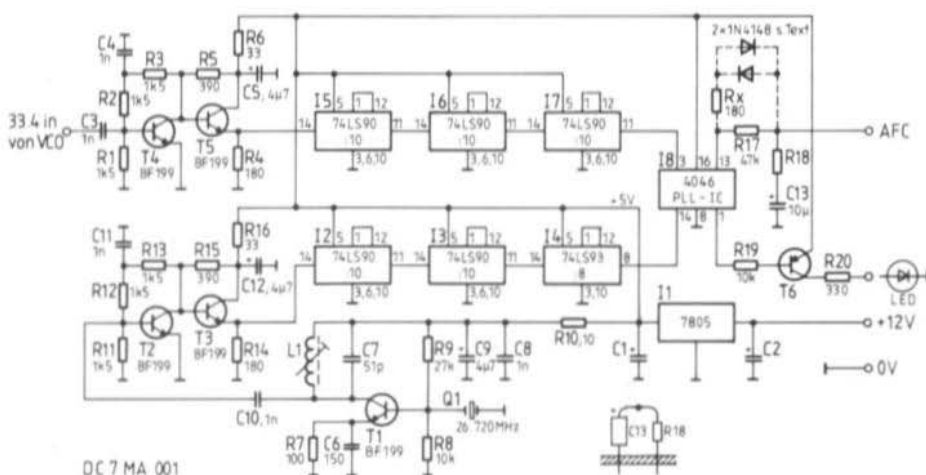


Fig. 6: The complete circuit of the new sound-PLL

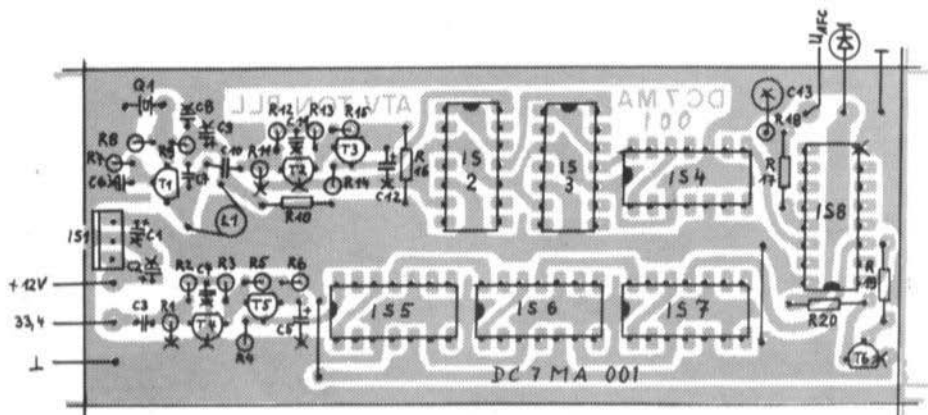


Fig. 7: Component plan of the 110 x 45 mm DC 7 MA 001 PCB

LED out = PLL functions normally

An additional circuit can be made which causes the transmitter to be suppressed, see **fig. 4**. Should the PLL not lock in, the supply voltage to the injection frequency (DJ 4 LB 003 or DJ 4 LB 004) is cut off. This prevents a faulty signal from being radiated.

1.5. Faster Lock-in Time

If the PLL is found to lock-in too slowly (approx. 0.75 s), a resistance diode combination can be placed across the 47 k Ω resistor R 17 of the loop filter. See **fig. 5**. The lock-in time is thereby shortened to a few ms and without influencing the deviation (2). See alteration for DF 6 WU 001.

2. CONSTRUCTION

Those interested in duplicating the complete circuit, should take **fig. 6** as a basis.

2.1. Printed Circuit Board

The printed circuit board (**fig. 7**) is fully copper-coated on the component side. High-frequency

components having ground connections are to be soldered to both sides of the board – this is difficult if IC sockets are employed. All the other holes must be counter-sunk on the component side to prevent undesired short-circuits to earth. This has been mentioned before in many previous articles. Care should be taken with the middle track of the PCB, it carries + 5 V.

As a small contribution to environmental considerations, the PCB was designed so that only a minimum of copper has to be etched away. This saves etch solution but on "scouts honour" **where does the used solution go?**

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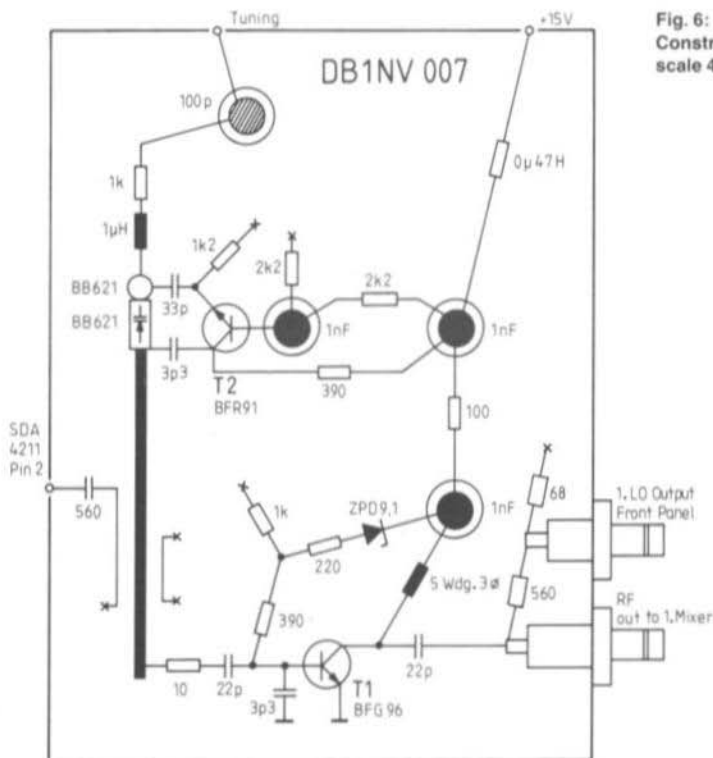


Fig. 6:
Constructional details of the VCO:
scale 4 to 1

layout plan of **fig. 5**. Only the VCO itself requires careful wiring as it is "rats-nest" wired. This is shown clearly in **fig. 6** with a scale of 4 to 1.

The varicap diodes are prone to hair-line cracking when subjected to mechanical stress. This manifests itself in unpredictable tuning behavior of the VCO and also in microphony. Also, the leadless disc capacitors, which have been used as wiring supports, exhibit the same sort of effects when they have been overheated during soldering. **Figure 7** shows a completed example of the module DB 1 NV 007 whilst **fig. 8** shows a close-up photograph of the VCO.

To commission the unit, a 15 V supply is connected and the 0 - 30 V tuning voltage applied directly to the varicaps (the 100 pF decoupling

capacitor is a convenient point), the line arriving from I3 being provisionally disconnected. The main output of the oscillator is measured by a power meter (20 mW range) and a frequency counter is connected to the second output. The VCO will oscillate at between 400 and 440 MHz when the tuning voltage is zero. At about 25 V, 1000 MHz will be obtained. The output power will be between 5 and 15 mW over the entire tuning range.

More important than the absolute values of frequency and power is the check-up of how they vary during tuning. Sudden changes in either quantity indicate spurious oscillation or parasitics. Both effects are usually the result of using wrongly dimensioned RFCs or components which have over-long connecting leads.

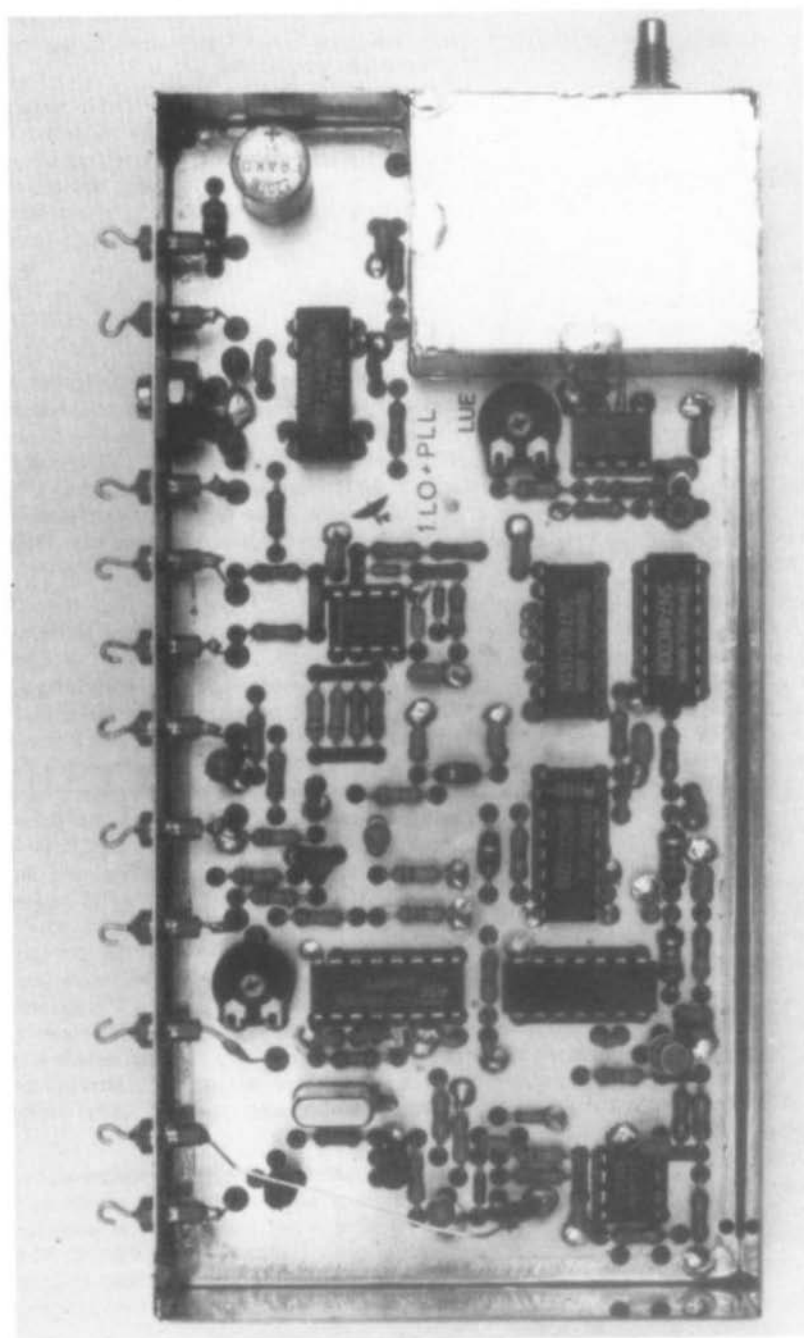


Fig. 7. A completed VCO PLL module



- a calibrated output attenuator
- highly stable power supply giving ± 15 V and + 30 V

1. THE HF/IF UNIT DB 1 NV 006

The circuit diagram of **fig. 1** was originally published in part 1 (fig. 2.3.) and represents the HF/IF signal processing. This circuit has been largely unaltered. The input signal in the range 0 - 1500 MHz is translated to a frequency of 470 MHz (1st IF) by means of a diode-mixer type SRA 220 supplied by a local oscillator working in the range 470 - 1000 MHz. The IF signal is passed to a BFR 90 amplifier via a 3-stage helical filter F1. The amplifier is then followed by a second helical filter F2. The overall gain of the 470 MHz stage lies between 5 and 10 dB.

The first IF is then translated to a second IF of 10.7 MHz in an IE 500 M18 (or similar) ring mixer, the latter being supplied by a varicap tuned 460 ± 3 MHz local oscillator. The resulting 2nd IF of 10.7 MHz is amplified by 26 dB in a 2-stage (T3 and T4) amplifier. The bandwidth of the amplifier is some 400 kHz and is the widest filter bandwidth used by the analyser.

The amplification of the IF stage can be varied, by means of a PIN diode in the emitter of T4, by up to 15 dB. This is the means by which a signal to be inspected is aligned to any given horizontal grid line on the trace in order that its amplitude characteristics can be compared.

The amplified 2nd IF at 10.7 MHz is taken out to a socket which has a crystal filter connected to it. The filtered 2nd IF is then taken back to the HF/IF unit and then on to the logarithmic demodulator. This detector is different from the earlier version, consisting of a single integrated circuit, TDA 1576 (Valvo). This IC was designed as a high-performance FM-IF stage, plus demodulator, for high-class radio tuners. It possesses, a nearly, dB-linear fieldstrength characteristic over a 90 dB range which is used in this application.

Even if the linearity is not as good as can be made with discrete components in a chain of rectifier-

amplifiers (the valvo data-sheet curves are a bit optimistic!), the IC is still worth using because of its extremely simple utility.

The advantage of combining HF and IF stages into one unit is, that when using a larger bandwidth, the crystal-filter unit can be left out of circuit by simply connecting the input and output connectors together. This can also be regarded as an easy-to-implement test of the unit's functioning.

1.1. Construction

It is important when obtaining the components, especially the semiconductors, that only brand-named items are chosen. Whilst the Tele Quarz 10H3 helix filter, on account of its dimensions, cannot be substituted by another type, it is possible to use other types of pin-compatible ring mixers than the specified ones from Mini-Circuit. In the same manner, I2 can be tried with the R & K Laboratories M18.

The tuned-circuit coils L1 to L7 can either be fabricated from coil kits in the series 7 (7 x 7 x 13 mm) or ready-made filters from Neosid may be employed. When constructing the helix filter, care should be taken to solder the long sides to the top side of the PCB. The pins connecting the ground plane should be carefully bent into a suitable position and soldered to the upper copper coating (ground plane) of the PCB. Only the input and output pins together with the fixing tabs are taken through the PCB. The fixing tabs must be soldered both to the ground plane and the track side of the PCB (through-contacted). The housing of the ring mixer and the emitter connection of T1 (BFR 90) are also soldered to the ground plane. The consequence of not attending correctly to these details is a lack of overall stage gain in the 470 MHz portion together with unstable bandpass curves during the sweep alignment.

During the installation of T4, it is recommended that a ferrite bead be slipped over the base lead. This measure is necessary to inhibit the possibility of spurious oscillations, in the 500 MHz region from occurring – experienced in some examples. This is manifest in the form of "ghost signals" on the trace.

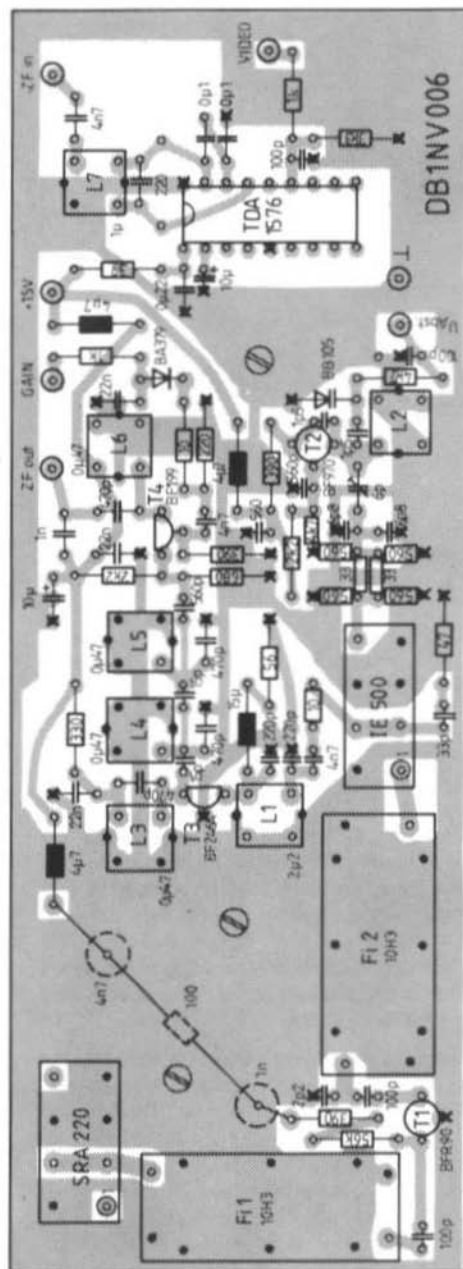


Fig. 2: HF/IF board component layout plan

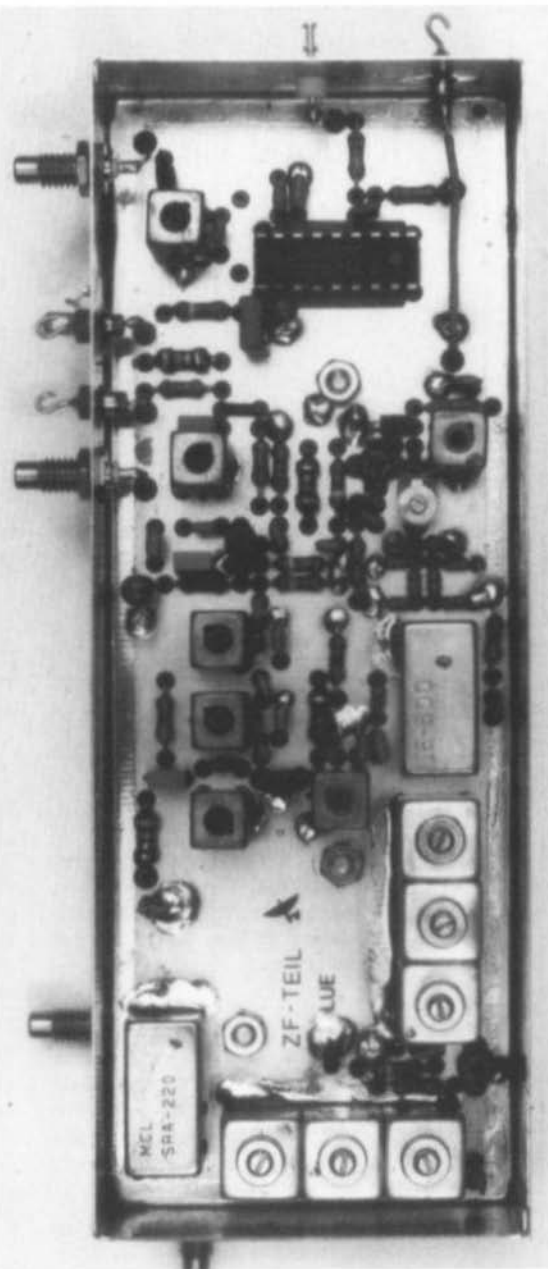


Fig. 3: A completed example of the HF/IF module



Thomas Morzinck, DD Ø QT

Oscilloscope Line-Analyzer Accessory

The unit to be described enables the selection and display of any single line on a standard oscilloscope. The circuit is designed for video sources having the standard output level.

1. INTRODUCTION

The last 10 years in the development of data processing, the emerging media has left its effect upon the video signal. The transmission of additional information signals, which are not intended for visible display, is evermore increasing.

Broadcast television offers its viewers VIDEO-TEXT and other similar services and VHS rent-films add signals according to the MACRO-VISIONS (2) technique. The SIS technique (Sound-in-Sync) has been decided upon for the transmission of high-fidelity sound, also data and marker signals can be encountered.

All these non-displayed signals are carried in the blanking and synchronizing portions of the video signal and cannot reliably be evaluated on a normal oscilloscope's trace. For this facility, a synchronizing frame must be prepared which is

able to be triggered in a definite and programmable manner from an external source.

2. PRINCIPLE

A synchronizing pulse circuit, which has been to the desired video input signal (level pos./neg.), primes the line and frame pulses. A counting circuit is started from the half frame picture which counts the horizontal pulses and produces, at a preselected point in time, an impulse for the external trigger input of an oscilloscope. This enables the presentation of a single line or series of lines to occur always at the same point in time (e.g. after the 10th line).

The number of displayed lines is selected on the oscilloscope by the horizontal speed control. The displayed time duration for only one line (64 μ s) is too short for the trace to have the required brilliance and therefore the brilliance control of the oscilloscope must be increased to maximum and/or the ambient lighting reduced. An oscilloscope hood would also be an advantage.

Should several lines be displayed at the same time, the trace brilliance increases propor-



tionally. Using a proprietary small service oscilloscope, a single, complete line can be made clearly visible; groups of about 10 to 15 lines are distinct even with a small screen size. The principle is shown clearly in **fig. 1**.

3. THE CIRCUIT

There have already been several circuits published (3), (4), which may also be classified into video, synchronizing or digital portions.

There are various possible solutions. The TBA 920, used here, and the TTL series ICs are not

state-of-the-art components but they are unproblematical in their employment and are probably already in the amateur's junk-box waiting for something useful to do (**fig. 2**).

Highly integrated solutions may be more elegant but do not allow the same sort of control over all the individual parameters. For signal sources which do not possess the normal synchronizing pulses (satellite television), an external re-constitution would be indispensable.

3.1. Video Amplifier

The video amplifier must match the input signal to the following sync.-pulse circuits. Standard video signals, e.g. from a video recorder (1 V_{pp}/75 Ω FBAS pos.), can be processed directly by

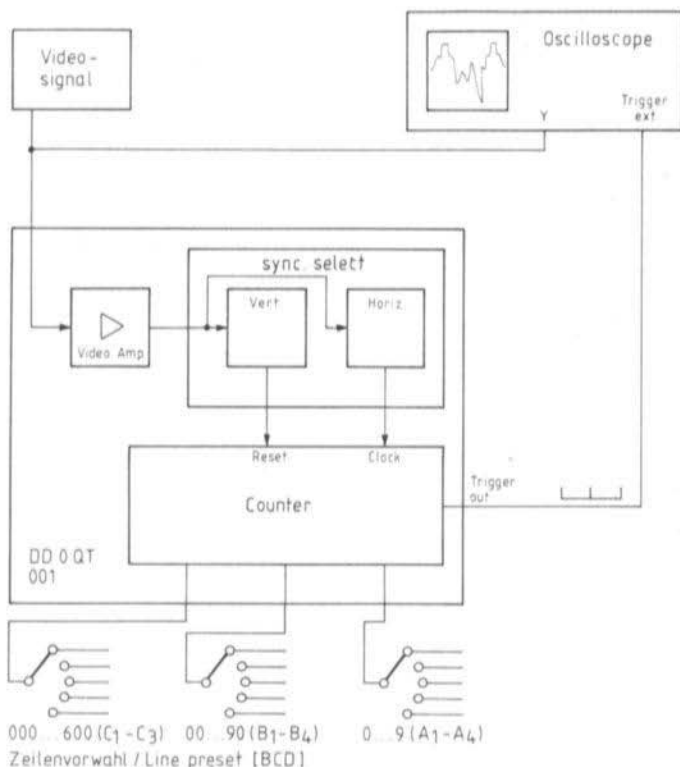


Fig. 1:
Principle of a video
line analyzer



a television LSI-IC (e.g. TDA 3701 (4) or TDA 2595 (5)).

The TBA 920 has been designed to work with positive sync. pulses from an input signal of at least 1 V and a pre-amplifier is therefore necessary. This was taken from (6).

When other video signals are to be displayed a suitable amplifier must be provided. Maybe several inputs with switchable signal processing would be the most convenient solution.

3.2. Sync. Separation

The composition of a typical television picture signal complete with sync. pulses will be assumed to be familiar to the reader.

The TV-IC TBA 920 is used in a standard circuit and connected in the video-record mode (pin 16 to ground). The capacitor at pin 14 (10 nF MKH) must have a very close tolerance as it is in a frequency-determining part of the circuit. It may be better to construct it from several smaller parallel capacitors to achieve the exact value. If this point is not observed, the horizontal oscillator will have a very limited capture range, or indeed, none at all! The half-frame impulses are extracted passively by means of an RC-network. The disadvantage of this simple circuit is manifest when parasitic pulses (e.g. MACROVISION) occur in the signal. This causes the irregular generation of spurious vertical pulses immediately after the half-frame impulse. In order to suppress these signals, the vertical signal is taken via an inverter stage to the first mono-

stable in the 74LS221 which generates a square-wave pulse whose width equals the duration of about 100 (uncritical) lines. It is triggered only from a genuine half-frame pulse and its leading edge flips the next bi-stable (74LS73).

This bi-stable is connected as a divide-by-two scaler and it suppresses every second half-frame impulse. Only by these means can the following counter be pre-adjusted to operate over the full number of lines (625).

In order to achieve a fixed relationship between the line sync. pulse, trigger signal, the counter is not reset by the half-frame pulse but by a horizontal sync. pulse. The relevant signal sequence is shown in **fig. 3**.

Following the suppression of any spurious half-frame pulse by MF 1 and every second half-frame pulse by the flip-flop, MF 2 produces an output pulse of the same width as a line length and which is used as a gate for the AND gates (2 x 74LS00).

At this time, the arriving pulse from the TBA 920 horizontal oscillator appears at the output of the inverter as a positive reset pulse for the following counter.

This manner of recovering the impulse has the following two disadvantages: —

- By using the horizontal pulse as a reset, the line following the selected line will be displayed on the screen.
- Since no account has been taken in the suppression of every second half-frame pulse in

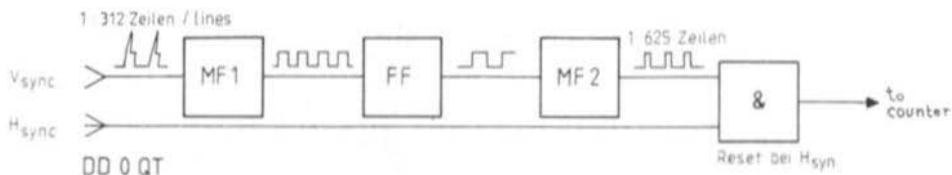


Fig. 3: Producing the counter reset input system

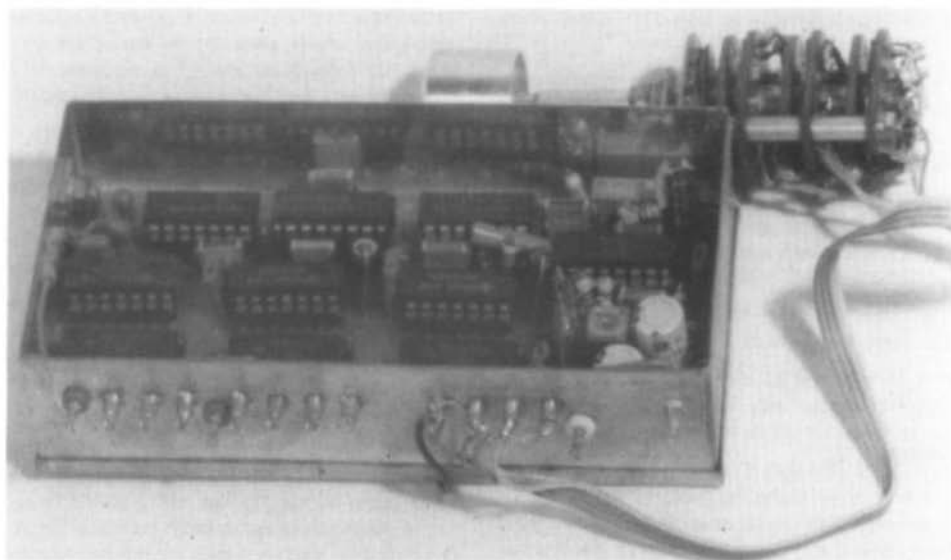


Fig. 4: The photograph shows an analyzer in a tin-plate frame, before it was built in a case. The unit is only provisionally wired for test purposes.

which half of the frame it is, it can occur that, when say, line 10 has been selected, line 323 is displayed.

For amateur purposes, both these disadvantages are largely irrelevant. A systematic displayed error of + 1 is very easily accommodated by the user.

The question of the half-frame can be settled quite quickly by observing the successive pulses, 5 = first half-frame, 4 = second half-frame.

3.3. The Counter

The processed sync. pulses are taken to a pre-adjustable counter. BCD types with negative outputs can be used for the switches or simple step switches with a suitable diode matrix. When the selected number has been reached, an impulse appears at the last 74 LS 85 which is used to trigger the oscilloscope.

4. CONSTRUCTION

Although a small number of working units have been constructed, this circuit was only intended as a basis for design. A reproducible PCB layout has therefore not been provided. A suitable PCB for the counter would be that of DK 1 OF 002 (7). The construction should be effected by equipping one circuit at a time and operationally testing it. Particular care should be taken with the adjustment of the TBA 920.

It is also possible to work with video sources having 525 lines at 60 Hertz. A very versatile measurement accessory for the oscilloscope can be built with switchable inputs to various pre-amplifiers polarities and external clock and reset inputs.



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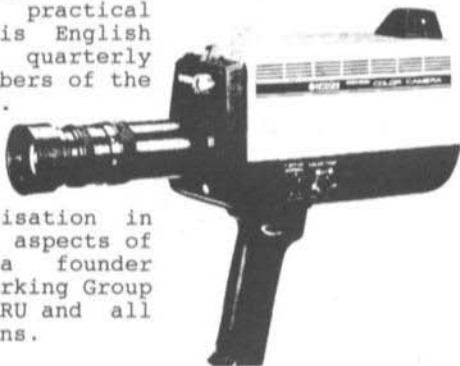
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	Set of PCBs, progr. EPROM, operating system V.7.2.	6004	DM 1050.-
	Contains: PCBs YT3MV 003 (bus), 004, 005, 006 (4 x), 007, 008 and 009; a programmed EPROM, the operating-system floppy, a set of copies of all diagrams and component lay-out plans (in A4), the operating-system manual.		
YT3MV 010	Interface for KR-5600 Rotators		ed. 1 + 2/89
	PCB, programmed EPROM, together with A4 copies of circuit schematics and component location plans	6003	DM 100.-
	User software		upon request
DCØDA	10 GHz Transverter System "microline 3"		ed. 2 + 3/89
XLO-1	Oscillator		ed. 2/89
Kit	Contains all original components in chapter 2.3.	6601	DM 178.-
XRM-1	Receive mixer		ed. 3/89
Kit	Contains all original components in chapter 3.3.	6603	DM 345.-
XTM-1	Transmit mixer		ed. 3/89
Kit	Contains all original components in chapter 4.3.	6605	DM 355.-
	Original Johannson trimming tool for μ W trimmer	6607	DM 18.50
DB1NV	Spectrum analyser 0 - 500/1500 - 1000 MHz		ed. 2 + 3/89
Ready-made unit	with 6-months guarantee	3303	DM 6.350.-
Completed modules (4)	aligned and tested	3302	DM 2.698.-
Component kit (four modules)	This kit contains the 4 PCBs DB1NV 006, 007, 008, 009, together with all required parts incl. the 4 drilled tin-plate housings with feed-thro's (caps + PTFE) and SMC sockets.	6005	DM 1.620.-



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- PC/AT or compatible with the following basic equipment:
 - 286-processor
 - 640 kbyte and 1 Mbyte (min.) extended memory
 - Hard disk drive with at least 6.5 Mbyte free
 - EGA card or higher
 - EGA monitor

User-friendly SOFTWARE

written in C and Assembler 286

- Automatic reception
- Reception schedule:
The reception menu contains all METEOSAT transmissions listed with both time and format. Automatic reception by simply "clicking it up".
- Picture format
All pictures are stored on the hard disk in full format. There are three picture presentation formats:
 - 800 x 800 full resolution
 - 640 x 350 reduced resolution
 - 640 x 350 geographically corrected
- Zoom/histogram
The pictures may be enlarged up to a factor at x10. A histogram is computed for the selected sector.
- Colour
A colour table comprising 50 selectable colours is available for various picture spectral ranges.
- Time lapse/movie of up to 16 pictures; can be moved forwards and backwards.

Ask for a Demo-program with satellite pictures (DM 20.-) together with further information - cash or check with order.

UKWtechnik

UKW-Technik
T. Bittan GmbH
P. O. Box 80, Jahnstraße 14
D-8523 Baidersdorf
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AFUSOFT PC-RADIOFAX

An all-round Radio Telefax program for the PC

PC-RADIOFAX offers picture transmission on the ATARI ST and MS DOS computers (XT/AT) for receiving radio weather charts and photofax. With a special "AM-OPTION BOARD", using the FAX converter MPSK, you can receive, store and process amplitude-modulated satellite pictures.

Performance notes:

- Simple operation using keyboard or mouse
- High-resolution picture transmission on monitor or printer
- Monochrom (black/white), grey-scale or colour representation
- Automatic phasing
- Manual phase readjustment without information loss
- Automatic picture transmission (APT)
- Automatic picture control store and load
- Zoom to different formats
- Inverse scan direction (ISD)
- Installed graphic editor for post processing
- File formats and technical information available

Applications:

- Amateur radio
- Maritime radio
- Press reports
- Professional monitor stations

Hardware configuration:

- ATARI ST or compatible PC with at least 1 Mbyte RAM
- Appropriate SSB-receiver, transceiver, satellite-receiving system
- Standard converter AFUSOFT MPSK equipped for SSTV and other picture modes

Options:

Printer, harddisk and plug-in modules (OPTION BOARDS) which fit into the MPSK.

	Art.No.	Price
PC-RADIOFAX incl. converter MPSK and handbook	5800	DM 950.00
PC-RADIOFAX for ATARI ST, incl. MSPK and handbook	5810	DM 966.00

Ask for our DEMO DISK (DM 20.00). Payment in advance please.



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We are the only European manufacturer to supply: miniature TCXO's

CCO 102, CCO 103, CCO 104, CCO 109, CCO 152 with modulation capability

Type	CCO 102			CCO 103			CCO 104			CCO 109			CCO 152		
	A	B	F	A	B	F	A	B	F	A	B	F	A	B	F
Stability	± 5 ppm			± 3 ppm			± 5 ppm			± 3 ppm			± 5 ppm		
Temperature range	-30 ... +60 °C		-10 ... +60 °C	-30 ... +60 °C		-10 ... +60 °C	-30 ... +60 °C		-10 ... +60 °C	-30 ... +60 °C		-10 ... +60 °C	-30 ... +60 °C		-10 ... +60 °C
Current consumption	max. 3 mA at UB = +5 V			max. 10 mA at UB = +5 V			max. 10 mA at UB = +5 V			max. 10 mA at UB = +5 V			max. 3 mA at UB = +5 V		
Output signal	-10 dBm/50 Ω			TTL-compatible (Fan-out 2)			0 dBm/50 Ω			TTL-compatible (Fan-out 2)			-10 dBm/50 Ω		
Housings	19 x 10 x 17 mm			G 103 20 x 20 x 10 mm			22,5 x 6,6 x 17,5 mm			G 123 12 x 18,8 x 9,5 mm			19 x 10 x 17 mm		
Frequency range	10 - 80 MHz			5 - 80 MHz			10 - 80 MHz			10 - 30 MHz			10 - 30 MHz		

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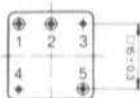
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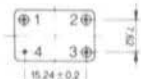
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